CIVIL ENGINEERING COLLEGE,

SIBPUR.

CALENDAR FOR 1892.

Calcutta:

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1892.

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CIVIL ENGINEERING COLLEGE, SIBPUR, CALENDAR.

ALMANAC 1892.

JANUARY 1892.

Date.	Day of week.	General and Office.	Engineer Department.	Apprentice Department.
1	F.	New Year's Day.		
2	S.	Christmas vacation ends.		
3	Sun.	2nd Sunday after Christmas.		
4	M.			
5	T.			
6	W.			
7	Th.			
8	F.			
9	S.			
10	Sun.	1st Sunday after Epiphany.		
11	M.			Admission examination begins.
12	T.			
13	W.			
14	Th.			
15	F.	Monthly fees due.		
16	S.			
17	Sun.	2nd Sunday after Epiphany		
18	M.			
19	T.			
20	W.			
21	Th.			
22	F.			
23	S.			
24	Sun.	3rd Sunday after Epiphany.		
25	M.			
26	T.	Monthly statement of fees due.		
27	W.			
28	Th.			
29	F.			
30	S.		Students return from survey camp.	
31	Sun.	4th Sunday after Epiphany.		

FEBRUARY 1892.

Date.	Day of week.	General and Office.	Engineer Department.	Apprentice Department.
1	M.			Session begins.
2	T.			
3	W.	Sree Punchamy, College holiday.		
4	Th.	Ditto ditto.		
5	F.			
6	S.			
7	Sun.	5th Sunday after Epiphany.		
8	M.			
9	T.			
10	W.			
11	Th.			
12	F.	Annual sports.		
13	S.			
14	Sun.	Septuagesima.		
15	M.	Monthly fees due.		
16	T.			
17	W.			
18	Th.			
19	F.			
20	S.			
21	Sun.	Sexagesima.		
22	M.			
23	T.			
24	W.			
25	Th.	Monthly statement of fees due.		
26	F.			
27	S.			
28	Sun.	Quinquagesima.		
29	M.			

MARCH 1892.

Date.	Day of week.	General and Office.	Engineer Department.	Apprentice Department.
1	T.			
2	W.	Ash Wednesday.		
3	Th.			
4	F.			
5	S.			
6	Sun.	1st Sunday in Lent.		
7	M.			Monthly examination begins.
8	T.			
9	W.			
10	Th.			
11	F.			
12	S.			
13	Sun.	2nd Sunday in Lent.		
14	M.			
15	T.	Monthly fees due.		
16	W.			
17	Th.			
18	F.			
19	S.			
20	Sun.	3rd Sunday in Lent.		
21	M.			
22	T.			
23	W.			
24	Th.			
25	F.	Monthly statement of fees due.		
26	S.			
27	Sun.	4th Sunday in Lent.		
28	M.			
29	T.			
30	W.			
31	Th.			

APRIL 1892.

Date.	Day of week.	General and Office.	Engineer Department.	Apprentice Department.
1	F.			
2	S.			
3	Sun.	5th Sunday in Lent.		Last day for admission of students who have passed University Entrance examination. Monthly examination begins.
4	M.		1st year test examination begins.	
5	T.			
6	W.	Accountant examination to be advertised in *Calcutta Gazette*.		
7	Th.			
8	F.			
9	S.	Accountant examination to be advertised in *India Gazette*.		
10	Sun.	6th Sunday in Lent.		
11	M.	Chaitsankranti, College holiday.		
12	T.			
13	W.			
14	Th.	Detailed statement of establishment due. Acknowledgment of permanent advance due.		
15	F.	Easter Holidays.		
16	S.			
17	Sun.	Easter Day.		
18	M.	Monthly fees due.	Last day of application for F. E. examination.	
19	T.			
20	W.			
21	Th.			
22	F.			
23	S.	Advertise admission to Engineer Department in *India Gazette*.		
24	Sun.	1st Sunday after Easter.		
25	M.	Annual Report due.		
26	T.			
27	W.			
28	Th.			
29	F.			
30	S.	Last day for submitting indent for chemical apparatus.		

MAY 1892.

Date.	Day of week.	General and Office.	Engineer Department.	Apprentice Department
1	Sun.	2nd Sunday after Easter.		
2	M.	Report of surveying instruments for repair due.	F. E. examination begins.	Monthly examination begins.
3	T.			
4	W.			
5	Th.			
6	F.	Last day for receiving applications for admission to Accountant examination.		
7	S.			
8	Sun.	3rd Sunday after Easter.		
9	M.			
10	T.			
11	W.		Practical examination of 1st and 2nd year classes begins.	
12	Th.			
13	F.			
14	S.			
15	Sun.	4th Sunday after Easter.		
16	M.	Monthly fees due.		
17	T.			
18	W.			
19	Th.			
20	F.			
21	S.			
22	Sun.	5th Sunday after Easter.		
23	M.		Last day for receiving applications for admission.	
24	T.	Queen's Birthday.		
25	W.	Monthly statement of fees due.	Theoretical examination, 1st and 2nd years, begins.	
26	Th.	Ascension Day.		
27	F.			
28	S.	Indent for stationery due.		
29	Sun.	Sunday after Ascension.		
30	M.			
31	T.			

JUNE 1892.

Date.	Day of week.	General and Office.	Engineer Department.	Apprentice Department.
1	W.			Monthly examination begins.
2	Th.			
3	F.			
4	S.			
5	Sun.	Whitsunday.		
6	M.	4th grade Accountant examination begins.	Opening of Session. New students join.	
7	T.			
8	W.			
9	Th.			
10	F.			
11	S.			
12	Sun.	Trinity Sunday.		
13	M.			
14	T.			
15	W.	Monthly fees due.		
16	Th			
17	F.			
18	S.			
19	Sun.	1st Sunday after Trinity.		
20	M.			
21	T.			
22	W.			
23	Th.			
24	F.			
25	S.	Monthly statement of fees due.		
26	Sun.	2nd Sunday after Trinity.		
27	M.	Indent for forms due.	Last day of application L. E. and B. E. examination.	
28	T.			
29	W.			
30	Th.			

JULY 1892.

Date.	Day of week.	General and Office.	Engineer Department	Apprentice Department.
1	F.			
2	S.			
3	Sun.	3rd Sunday after Trinity.		
4	M.			Monthly examination begins.
5	T.			
6	W.			
7	Th.			
8	F.			
9	S.			
10	Sun.	4th Sunday after Trinity.		
11	M.		L. E. and B. E. examination begins.	
12	T.			
13	W.			Final examination, 4th year, begins.
14	Th.			
15	F.	Monthly fees due.		
16	S.			
17	Sun.	5th Sunday after Trinity.		
18	M.			Practical examination, 1st, 2nd, and 3rd years.
19	T.			
20	W.			
21	Th.			
22	F.			
23	S.			
24	Sun.	6th Sunday after Trinity.		
25	M.	Monthly statement of fees due.		Final practical examination, 4th year, begins.
26	T.			
27	W.			
28	Th.			
29	F.			
30	S.	Budget estimate due.		
31	Sun.	7th Sunday after Trinity.		

AUGUST 1892.

Date.	Day of week.	General and Office.	Engineer Department.	Apprentice Department.
1	M.			
2	T.			
3	W.			Annual theoretical examination, 1st, 2nd, and 3rd years.
4	Th.			
5	F.			
6	S.			
7	Sun.	8th Sunday after Trinity.		
8	M.			
9	T.			
10	W.			
11	Th.	Monthly fees for August and September due.		
12	F.			
13	S.			
14	Sun.	9th Sunday after Trinity.		
15	M.	College closes for long vacation.		
16	T.			
17	W.			
18	Th.			
19	F.			
20	S.			
21	Sun.	10th Sunday after Trinity.		
22	M.			
23	T.			
24	W.			
25	Th.	Monthly statement of fees due.		
26	F.			
27	S.			
28	Sun.	11th Sunday after Trinity.		
29	M.			
30	T.			
31	W.			

SEPTEMBER 1892.

Date.	Day of week.	General and Office.	Engineer Department	Apprentice Department.
1	Th.			
2	F.			
3	S.			
4	Sun.	12th Sunday after Trinity.		
5	M.			
6	T.			
7	W.			
8	Th.			
9	F.			
10	S.			
11	Sun.	13th Sunday after Trinity.		
12	M.			
13	T.			
14	W.			
15	Th.			
16	F.			
17	S.			
18	Sun.	14th Sunday after Trinity.		
19	M.			
20	T.	Mohaloya Holiday.		
21	W.			
22	Th.			
23	F.			
24	S.	Monthly statement of fees due.		
25	Sun.	15th Sunday after Trinity.		
26	M.	Durga Pujah Holidays.		
27	T.			
28	W.			
29	Th.			
30	F.			

OCTOBER 1892.

Date.	Day of week.	General and Office.	Engineer Department.	Apprentice Department.
1	S.			
2	Sun.	16th Sunday after Trinity.		
3	M.			
4	T.	Durga Pujah Holidays		
5	W.			
6	Th.			
7	F.			
8	S.			
9	Sun.	17th Sunday after Trinity.		
10	M.			
11	T.			
12	W.			
13	Th.			
14	F.			
15	S.			
16	Sun.	18th Sunday after Trinity.		
17	M.			
18	T.			
19	W.	Kali Pujah.		
20	Th.			
21	F.			
22	S.			
23	Sun.	19th Sunday after Trinity.		
24	M.			
25	T.	Monthly statement of fees due.		
26	W.			
27	Th.			
28	F.			
29	S.			
30	Sun.	20th Sunday after Trinity.		
31	M.	Juggodhatree Pujah.		

NOVEMBER 1892.

Date.	Day of week.	General and Office.	Engineer Department.	Apprentice Department.
1	T.			
2	W.			
3	Th.			
4	F.			
5	S.			
6	Sun.	21st Sunday after Trinity.		
7	M.	College re-opens after long vacation.		
8	T.			
9	W.			
10	Th.			
11	F.			
12	S.			
13	Sun.	22nd Sunday after Trinity.		
14	M.		Surveying for 1st year begins.	Surveying for 2nd, 3rd, and 4th years begins.
15	T.	Fees for October and November due.		
16	W.	Advertise admission examination to Apprentice Department in *Calcutta Gazette*.		
17	Th.		Surveying for 3rd year begins.	
18	F.			
19	S.	Advertise admission examination to Apprentice Department in *India Gazette*.		
20	Sun.	23rd Sunday after Trinity.		
21	M.			
22	T.			
23	W.			
24	Th.		Surveying for 2nd year begins.	
25	F.			
26	S.			
27	Sun.	1st Sunday in Advent.		
28	M.			
29	T.			
30	W.			

DECEMBER 1892.

Date.	Day of week.	General and Office.	Engineer Department.	Apprentice Department.
1	Th.			
2	F.			
3	S.			
4	Sun.	2nd Sunday in Advent.		
5	M.			
6	T.			
7	W.			
8	Th.			
9	F.			
10	S.			
11	Sun.	3rd Sunday in Advent.		
12	M.		Annual tour of senior students begins.	
13	T.			
14	W.			
15	Th.	Monthly fees due.		
16	F.			
17	S.			
18	Sun.	4th Sunday in Advent.		
19	M.			
20	T.			
21	W.			
22	Th.			
23	F.	Christmas vacation begins.		
24	S.			
25	Sun.	Christmas Day.		
26	M.			
27	T.			
28	W.	Monthly statement of fees due.		
29	Th.			
30	F.			Last day for receiving applications for permission to appear at admission examination.
31	S.			

CIVIL ENGINEERING COLLEGE, SIBPUR.

Board of Visitors.

1.	Secretary to the Government of Bengal, Public Works Department	*Ex-officio.*
2.	Director of Public Instruction, Bengal.	
3.	Joint-Secretary, Government of Bengal, Public Works Department.	
4.	Civil Surgeon, Howrah.	
5.	Inspector of Schools, Presidency Circle.	
6.	Principal, Civil Engineering College, Sibpur.	
7.	Executive Engineer, Calcutta Workshops Division.	
8.	Magistrate of Howrah.	
9.	Superintendent of Works, Calcutta.	
10.	Babu Kunja Lal Banerjea.	
11.	W. H. Ryland, Esq.	
12.	Babu Bhudev Mukerjea.	
13.	Mahamahopadhyay Mahes Chandra Nyaratna, C.I.E.	
14.	The Lord Bishop of Calcutta.	
15.	Maharajah Sir Jotendra Mohan Tagore, K.C S.I.	
16.	Brigade-Surgeon G. King, M.B., LLD., F.R.S., C.I.E.	
17.	F. J. E. Spring, Esq.	

COLLEGE STAFF.

Principal and Professor of Engineering ... J. S. Slater.

Engineer Department.

Professor of Mathematics	A. Macdonell, M.A.
Officiating Professor of Surveying ...	B. Heaton.
Professor of Physical Science ...	P. Brühl.
Professor of Drawing	J. T. Bartlett.
Assistant to Professor of Physical Science	Babu Upendra Nath Mitra.

Apprentice Department.

Head Master and Lecturer on Physical Science	R. W. F. Shaw, M.A.
Teacher	Dwarkanath Dutt.
Do.	Surendra Kumar Bose, B.C.E. (on leave).
Do.	Nobo Kumar Chakravarti, L.E.
Officiating Teacher	Hari Charan Mukerjee, L.E.

Workshops.

Executive Engineer, Calcutta Workshops Division	J. H. Toogood. A.K.C.L.
Foreman Instructor	W. G. Lawrence.

Ten native Instructors.

Hostels.

Superintendent of European Mess ...	R. W. F. Shaw, M.A.
Ditto Native Mess ...	Ashutosh Ganguli.

Medical Officer.

Assistant Surgeon Dino Bandhu Dutt, Honorary Assistant Surgeon to His Excellency the Viceroy.

CIVIL ENGINEERING COLLEGE, SIBPUR.

ENGINEER DEPARTMENT.

GENERAL RULES.

1. The College is under the general supervision of a Board of Visitors appointed by the Government.

2. The Principal of the College is charged with the general control of the institution, including the regulation of the course of study, the supervision of the mess and other domestic arrangements, and the maintenance of discipline; and he will from time to time issue such rules as may be necessary to secure those objects. The workshops are under the control of the Superintendent, and the students while at work in them will be under his orders, but all breaches of discipline will be reported by him to the Principal.

Rules for Admission.

3. For admission to the Engineer Department, a student must have passed one of the following tests:—

(1) The Entrance Examination of the Calcutta University, and in English and Mathematics must have obtained at least 40 and 50 per cent. respectively of the marks allotted to those subjects. The candidate's age must be under 19 years.

(2) The F.A. Examination of the Calcutta University. The candidate's age must be under 21 years.

(3) The B.A. Examination in the B. course. The candidate's age must be under 23 years.

4. Every candidate for admission to this Department must apply in writing to the Principal not later than the 25th May, furnishing satisfactory proof of his having passed the Entrance Examination.

5. Every applicant, before admission to the College, will be examined by the College Surgeon as to his physical strength, fitness for manual labour, and eyesight. If this officer's report is unsatisfactory, the applicant will not be admitted.

6. Each student received into the College will be required to pay an admission fee of Rs. 10.

7. The session begins on the first Monday in June. All students are required to join the College on that day. Any student prevented by sickness from attending on the opening day must produce a certificate to that effect from a Civil or Assistant Surgeon, failing which he will be liable to a fine not exceeding Rs 10. No student will be admitted or re-admitted to the College after the close of the month of June, except by special order of the Director of Public Instruction. This permission will only be given under exceptional circumstances.

Course of Instruction.

8. The course of instruction in the Engineer class will extend over five years, during the first four of which the instruction will be both theoretical and practical. The last year will be spent entirely in practical work. For details of the course of study, *see* Syllabus attached.

9. The students of the Engineer Department will be divided into sections—A, Civil; B, Mechanical.* Both sections will attend the same lectures for the first three years, and the students will then present themselves at the first examination in Engineering of the Calcutta University, which is held in the month of May. After passing this examination the sections will separate, the students of each section attending only those lectures which will enable them to qualify at the examinations of the Calcutta University for degrees or licenses in Civil or Mechanical Engineering.

* This section has not yet been established.

10. After the expiration of one year from the date of passing the first examination in Engineering, students will be qualified to appear at the University examination for degrees or licenses.

Extract from the "Calcutta Gazette" *of the* 16*th March* 1887, *page* 79, *Part IB.*

A candidate for employment as District Engineer must be qualified in one of the manners following, that is to say, he must—

(5) Hold the degree of Bachelor of Engineering or be Licentiate of Engineering of the Calcutta University, and have been employed on engineering works for not less than five years, exclusive of any time spent on apprenticeship, and hold satisfactory certificates of good conduct and efficiency during such employment.

11. After qualifying for a University degree or license in Engineering, every student will be employed for one year on practical work only, either in the workshops or on works in progress. On completing this course to the satisfaction of the College authorities, he will be entitled to receive the final College certificate.

12. A student failing at either the first or the second University examination may, with the sanction of the Director of Public Instruction, on the recommendation of the College authorities, be permitted to attend the College for one year more in order to re-appear at the examination; but no student will be allowed to attend the College course after the expiration of five years from admission. A student failing at the second examination will be allowed to attend the practical course for one year. The final College certificate shall state whether the student has or has not taken the University degree in Engineering and in which branch, and whether he has or has not completed the course of practical work to the satisfaction of the College authorities. A College certificate gives the holder no claim to a Government appointment.

13. Students will attend daily in the class-room and in the workshops in accordance with the College time-table. The hours of

work may vary with the seasons of the year. The fourth-year class is excused from work in the shops.

14. There will be a long vacation from about the middle of August to the end of October. Every student must leave the College during this vacation, and parents or guardians must satisfy the Principal, before their sons or wards can be admitted, that they are able to conform to this rule. The period from the middle of November to the end of January will be occupied in survey work.

Tuition Fees.

15. The tuition-fee for students of the Engineer class is Rs. 8 a month for each month of the year, vacation included.

Scholarships.

16. For the present, one junior scholarship of the value of Rs. 20 a month, three of Rs. 15 a month, and six of Rs. 10, tenable for two years, will be given annually to students entering the first-year Engineer class who do not already hold University scholarships. The scholarships will be awarded by the Director of Public Instruction on the last day of June to the following classes of students in order :—(1) B.As. who have taken up the B. course; (2) F.A. candidates;* (3) Entrance candidates according to the number of marks gained in English and Mathematics jointly.

17. Senior scholarships of the same number and value will be competed for at the annual examination held in May for the promotion of students from the second to the third-year class.

18. The number of College scholarships awarded, whether junior or senior, will in no case exceed one-half of the number of candidates for them.

19. Two scholarships of Rs. 10 a month each, tenable for one year, called Forbes' scholarships, will be awarded on the result of the first examination in Engineering of the Calcutta University. A Forbes' scholar, unless he also holds a College scholarship, will be exempted from paying the tuition-fee of Rs. 8 a month.

20 On the result of the University Examination for degrees and licenses, two graduate scholarships of Rs. 100 each and six of Rs. 50 each will, for the present, be awarded to those students who pass the best examination. The scholarships of Rs. 100 a month will be reserved for holders of the B.E. degree, *i.e.*, those who have passed the F.A. examination. All the eight scholarships will be tenable for one year, provided that the students are continuously employed during that period in practical work under the supervision of the Public Works Department, and to the satisfaction of those under whose orders they may be placed.

21. A gold medal will be awarded to the student who gains the highest marks in mathematics at the examination for the B.E. degree. The holder of this medal will be styled the "Ambica Churn Chaudhuri Medalist."

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* Except those who passed in the 3rd Division

Scholarships.

22. All scholarships will be liable to forfeiture in case of misconduct or of neglect of work in class or in the field, or of failure to pass any prescribed examination.

Standing orders for Students.

23. Except with the special sanction of the Principal, students of the Engineer Department will be required to reside on the College premises, so far as the accommodation will permit, at a rent to be fixed from time to time by the Government. The present rate is Rs. 2 a month for both European and native students.* This charge will be levied all the year round except during any period in which the student may be in camp.

24. Each resident student must provide his own clothing and bedding and a camp bedstead. No furniture may be brought into the College without special permission.

European Mess.

25. Every resident European student will join the European mess. A charge of Rs. 20 a month will be made to defray the cost of messing. During the vacation, reckoned at 2½ months, each European student will be required to pay monthly, in addition to Rs. 2 for house-rent, a contribution of Rs. 2 towards the cost of maintaining mess-servants.†

26. On joining the mess, every student will pay an entrance fee of Rs. 10 to the mess fund to provide for the cost of crockery, knives and forks, table-linen, &c. A list of breakages and other damage done will be prepared monthly, and each student will be required to pay, by the 15th of the following month, an equal share of the cost. On leaving the mess, if a student has paid all demands, his entrance fee will be returned to him; otherwise it will be forfeited to the mess fund.

27. For students joining the European mess, the following table shows the annual cost of living at the College, the term being reckoned as nine months and-a-half and the vacation as two months and-a-half of the year:—

	Tuition per mensem.	Board per mensem.	House-rent per mensem.	Total monthly charges.	Total per annum.	Grand total.
	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.
Term	8	20	2	30	285	315
Vacation	8	2	2	12	30	

Native Mess.

28. Hindu students residing on the College premises must ordinarily join the College mess for natives, and must abide by the rules sanctioned

* Native students now in the College and paying Re. 1 a month house-rent will continue to pay this sum only.

† European students have, at their own request, established a private mess, the cost of which is about Rs. 30 per mensem.

by the Principal for the management of their mess. Each student on joining the mess will be required to deposit "caution-money" to the amount of Rs. 5, which will be ultimately returned to the student if he has not rendered himself liable to the forfeiture of the whole or any part of it.

29. A charge of Rs. 7 a month will be made to those joining the native mess. During the vacation of two months, every member of the mess will be required to pay monthly, in addition to Rs. 2 for house-rent, a contribution of Re. 1 for mess-servants.

30. For students joining the native mess, the following table shows the annual cost of living at the College, the term being reckoned as nine months and-a-half and the vacation as two months and-a-half of the year:—

	Tution per mensem.	Board per mensem.	House-rent per mensem.	Total monthly charges.	Total per annum.	Grand total.
	Rs.	Rs.	Rs.	Rs.	Rs. A.	Rs.
Term	8	7	2	17	161 8	189
Vacation	8	1	2	11	27 8	

31. All payments, whether on account of tuition-fees, messing or house-rent, must be made into the Principal's office on or before the 15th of the month for which the money is due, after which date no payment will be taken unless accompanied by a fine of Re. 1 for every three days of delay. If the payment is not made during the month for which it is due, the defaulting student's name will be struck off the College books, and he will not be re-admitted until he has paid all arrears with fines and the usual re-admission fee.

32. The monthly charge for messing may, if necessary, be altered from time to time in reference to the prices of provisions.

33. All breaches of discipline committed by any student of the College will be reported to the Principal, who will dispose of them according to the rules and practice of the Education Department.

34. A Conduct Register of each student in the College will be kept by the Principal. The Principal has no power to cancel or alter an entry once made and signed.

35. Students are liable to have their names placed in the Conduct Register as defaulters for the following offences:—

(I) Disobedience of orders.
(II) Absence without leave.
(III) Idleness.
(IV) Insubordination or disrespect to the College or Workshop authorities.

36. Students may be removed from the College for habitual or gross misconduct, for continued idleness or neglect of work, or for frequent entry in the Conduct Register. Every such removal shall be reported to the Director of Public Instruction, and any fees paid by the student shall be forfeited.

37. Every student will be responsible for any machines, tools or other articles that may be placed in his charge. He must produce them

when called upon to do so, and must at once report any damage done to them. In case of loss or damage arising from carelessness, he may be called upon to pay the cost.

38. A certain number of the students will be appointed monitors, whose duty it will be to assist the College authorities in the maintenance of discipline. For the performance of this duty, each monitor will receive a small sum monthly. Any monitor may be removed by the Principal for misconduct, or for inefficiency in the discharge of his duties.

39. No resident student will ordinarily be allowed to keep a private servant. This permission may be given under exceptional circumstances, but any servant so employed will be under the orders of the Principal.

40. On Sundays all resident Christian students, Protestant or Roman Catholic, will be required to attend the services held in their respective chapels.

41. All students will be required, while in the workshop, to wear a uniform dress, which will be supplied to them at cost price.

42. Leave will be granted by the Principal only. No leave will be granted except on a written application.

43. No resident student may leave the College premises without the written order of the Principal, whether on special leave or on a general holiday.

44. European students will be encouraged to join the Volunteer Corps. Those who join it will be allowed such occasional leave as may be required by the regulations relating to volunteers.

45. One and two appointments in alternate years are now guaranteed to students of the College. The selected men are posted as Apprentice or Assistant Engineers in the Public Works Department.

46. All students are obliged to join the College Athletic Club the subscription to which is Re. 1-8 per annum and the entrance fee Re. 1.

ENGINEER DEPARTMENT.

SYLLABUS OF INSTRUCTION.

1.—MATERIALS OF CONSTRUCTION.

CLASSIFICATION ... { (*a*) Stone, brick, tiles, terra-cotta, timber, metals.
(*b*) Limes, cements, mortars, concretes, plasters.
(*c*) Mastics, glue, paints.

STONE.

Characteristics of Building Stone.—Durability dependent on atmospheric influence and physical structure. Facility of working; hardness; strength; weight; appearance; position in quarry; seasoning; natural bed; agents which destroy stone.

Examination of stone.—Fracture. Tests:—crushing; absorption; Brard's test; acid test; Smith's test. Practical way of ascertaining weathering qualities.

Classification of stone. Scientific.—Siliceous, argillaceous, and calcareous; *Practical.*—Granites and other igneous rocks; slates; sandstones; limestones.

Granite.—Common granite. Syenite and syenitic granite; quarrying and dressing: uses to which granite is applied.

Igneous rocks other than granite.—Porphyry, gneiss, mica schist, hornblende schist, trap, basalt.

Slates.—Cleavage, plerry, quarrying, hardness, toughness, grain, veins objectionable, pyrites. Tests.

Sandstones.—Composition, colour. Practical classification. Fracture a test of quality. Weight and absorption.

Limestones.—Composition, texture, marbles, compact limestones, granular limestones, shelly limestones, dolomite.

Artificial stone.—Ransome's, Sorel's, Victoria stone, Garlick stone.

Preservation of stone.—Bituminous matter, drying oil, silicate of potash, silicate of lime.

Quarrying.—Mode of conducting quarrying operations in India. Blasting.

BRICKS, TILES AND TERRA-COTTA.

Brick-earths.—Effect of the following ingredients in brick-earths:—Alumina, silica, lime, carbonaceous matter, alkalies, salt, oxide of iron, reh.

Practical classification—Strong clays; loams, marls, malm.

Composition of a good brick-earth. Colour of bricks.

Brick-making—Preparation of brick-earth:—Unsoiling, digging and weathering, grinding, washing, tempering.

Moulding.—Slop moulding, sand moulding, pallet moulding, frog, form of mould, and size of brick.

Drying.—In sheds, out of doors, hacking, scintling.

Burning.—In clamps, in kilns, amount of fuel required, comparative advantages of clamp and kiln burning, Hoffmann's kiln, Bull's kilns.

Characteristics of good bricks.—Freedom from flaws, shape, absorption, texture.

Tests for bricks.—Fractured surface, Brard's test..

Fire-clay.—Uses, where found, composition.

Tiles.—Preparation of clay, moulding pot, and flat tiles, various forms of tiles in use in India.

Terra-cotta —Nature of clay, preparation of clay, moulding, glazing, burning.

Limes, Cements Mortars, Concretes, Plasters.

Constituents of limestone that do not produce hydraulicity.—Carbonate of lime, sand.

Constituents that produce hydraulicity.—Clay, soluble silica, carbonate of magnesia, alkalies, sulphates.

Classification of limes and cements.—Fat limes, poor limes, hydraulic limes, cements.

Varieties of lime in common use.—Fat limes, grey chalk, lias, carboniferous, magnesian ; limestones used in India ; kunkur.

Artificial hydraulic lime. Natural cements.—Carbonate of magnesia, cement stones.

Roman cement.—Weight, strength, storing, uses. Medina and Atkinson's cements.

Artificial cements. Portland cement.—Manufacture from chalk and clay. Manufacture from limestones and shale. Tests of quality. Rough tests. Storing.

Strength when mixed with sand. *Scott's cement. Selenitic cement. Pasley's cement.*

Lime and cement burning.—Forms of kilns. Flare and tunnel kilns. *General rules for burning.*—Heat gradually applied, temperature, size of lumps, quantity of fuel, appearance of stone while burning. Overburnt and underburnt cements. Dead burnt lime.

Sand.—Pit sand, river sand, sea sand, screening and washing sand. Examination of sand.

Pozzuolanas.—Natural and artificial pozzuolanas.

Mortar—Ordinary mortar, cement mortar. Evils of fat limes. Hydraulic limes. Cements. Description of sand to be used in mortar.

Water.—Salt water, dirty water.

Preparation, and mixing mortar.

Slaking lime.—Quantity, time. Ground lime. Water.

Mixing.—Methods, quantities ; bulk of mortar produced.

Precautions in using mortar.

Concrete.—The matrix. The aggregate ; shape, size. Aggregates in common use :—Broken brick. Burnt clay. Gravel. Ballast Slag. Voids *Proportion of ingredients. Mixing :*—Materials all mixed together: mixed separately. Relative advantages of the two methods.

Laying concrete :—In trenches. Under water. *Bulk of concrete produced. Expansion of concrete. Uses of concrete.* Coignet's Béton. *Strength of concrete. Monolithic structures in concrete.*

On the action of foreign constituents in limestones and cements. Fat limes :—Calcination. Slaking. Setting. Mortar. Action of sand. *Hydraulic limes and cements containing clay.*—Clay. Lime. Calcination. Proportion of clay. Effect in cements burnt at a moderate temperature. Effect in cements burnt at a high temperature. Composition of clay. Effects caused by different degress of calcination Hydraulic limestones. Cement stones containing a small proportion of clay. Cement stones containing a large proportion of clay. Slaking. Setting. Proportion of clay. Pozzuolana. Carbonate of magnesia. Sulphates.

Plasters :—Lime and cement plaster. Gypsum. Plaster of Paris. Stucco.

Asphaltes :—Characteristics of good asphalte. Methods of laying. Uses.

White-wash.

Paints and Varnishes.

Paints. Distemper. Varnish. Mastics. Glazing. Papering.

Timber.

Growth of trees.—Annual rings, medullary rays, sapwood, heartwood, felling, squaring.

Characteristics of good Timber.

Defects in timber.—Heartshakes, starshakes, cupshakes ; rind galls, upsets, foxiness, twisted fibres.

Classification of timber.—Pine wood or soft wood, leaf wood or hard wood.

Seasoning timber —Natural seasoning, water seasoning, boiling and steaming, hot air seasoning, smoke-drying, scorching and charring.

Causes of decay in timber.—Continued dryness ; continued moisture ; alternate dryness and moisture ; continued moisture with heat. Dry rot. Positions in which dry rot occurs. Detection of dry rot, checking dry rot. Wet rot. Positions in which wet rot occurs.

Destruction of timber by insects.—Destruction by marine animals and whiteants, and modes of protecting timber from their attacks.

Preservation of timber.—By good ventilation and obviating moisture. By the use of oil paint. By the application of tar boiled with powdered chalk. Bethell's process of creosoting. Boucherie's process of injecting sulphate of copper. Margary's process. Payne's process.

Measurement of timber.

Metals.

Iron ores.—Blackband. Red and brown hœmatite, magnetic, spathic, argillaceous.

Preparation of ores.—By washing. By roasting in clamps and in kilns.

Smelting.—Description of blast furnace. Hot blast. Cold blast. Flux, slag. Comparative advantages of hot and cold blast iron.

Pig iron.—Foreign substances in pig iron. Carbon in a state of mechanical mixture and in chemical combination with cast iron. Effects of the following impurities upon cast iron, wrought iron and steel:—Silicon, phosphorus manganese, sulphur.

Cast iron.—Remelting pig iron. Grey and white cast iron, mottled cast iron. To distinguish grey from white. Chilled iron. Malleable cast iron. Toughened cast iron. Descriptions of pig iron for casting in sand. Pattern. Cold shut, core, head, casting pipes, examination of castings, cast iron pipes, tests for cast iron.

Production of Wrought Iron.

Effect on pig iron of.—Refining, puddling, shingling, rolling: contraction of wrought iron, defects in wrought iron, cold-short, hot-short, or red-short. Mitis castings.

Tests for wrought iron—Tensile strength. Ductility. Methods of testing. Tensile tests, forge tests, testing rivets, appearance of fractured surface.

Market forms of wrought iron.

Production of Steel.—Amount of carbon in steel. Characteristics: —hardening, tempering. Varieties of steel; blister steel; spring steel; shear steel; cast steel; Bessemer process; Siemens-Martin process; Basic process.

Hardening and tempering steel—Table of temperatures and colours. Degree of heat for hardening and methods of cooling. Hardening and tempering in oil.

Case hardening.

To distinguish steel from wrought iron. Testing steel.

Forging iron.—The form to be given to forgings, overheating.

Forging steel.—Shear, blister and cast steel.

Welding.—Wrought iron, steel.

Preservation of iron.—Corrosion, galvanising, painting, Dr. Angus Smith's process for cast iron pipes, Barff's process, Bright iron work.

2.—CONSTRUCTION.

Brick-Laying.

General principles of brickwork. Bond.

Operations of brick-laying. Bond timber objectionable. Mortar joints. Fine joints. Lime putty.

Precautions against settlement. Joining new work to old. String courses and copes. Stone quoins.

Scaffolding.

Masonry.

General principles of stone masonry. Ashlar. Block in course. Coursed rubble. Common rubble. Rubble backing. Strength of a mass of masonry as depending on the size of stones, the bond, and accuracy in dressing. Bonding—headers and stretchers; through bonds.

Quoins. Direction of beds in battering walls. String courses and copes. Pointing. Drystone masonry. Mechanism for moving large stones.

Instruments used in building. Scaffolding.

Earthwork.

Preliminary arrangements to be undertaken by the Engineer. Preparation of plan and sections. Practical stability of earthwork. Of excavation in rock.

Setting out of earthwork. Base or formation level. Sides or slopes. Half breadths. Computation of volume of a piece of earthwork. Simpson's rule for volumes. Prismoidal formula. Use of tables in such computations. Setting out. Angles. Centre line. Side widths; on side-long ground. Use of the bevil plumb rule, clinometer, mason's level, and boning staves.

Execution of earthwork. The tools and implements used. Size and form of barrows. Distribution of labour. Dobbin carts. Earth wagons. Boring to ascertain nature of ground.

Cuttings. Equalisation of cuttings and embankments. Side cuttings. Spoil banks Stripping the soil. The consecutive operations in forming a heavy cutting. The horse run with large barrows. Casting up by stages. Slips. Drainage

Embanking and puddling. Preferable materials for embankments. Embankments formed in one layer. In two or more thick layers. Settlement of embankments. Side slopes, facing slopes. Embanking in side-long ground. Foundations of embankments. Punning. Trimming slopes.

Carpentry.

Joints and Fastenings.

Joints.—Lapping, fishing, scarfing. Different forms of scarf. Halving. Dovetails. Notching. Cogging. Mortise and tenon joint. Chase mortises. Circular joints. Bridle joints. Post and beam joints. Strut and beam joints. Tie and brace joints. Suspending pieces. Wedging. Fox-wedging. Keys.

Fastening. Pinning:—Nails, spikes, trenails, screws. Bolts, washers, plates. *Straps:*—Heel straps, branched straps. Cast-iron shoes and sockets. Tie-beam plates. Shoe for foot of rafters. Double shoe. Socket pieces. Protection of iron fastenings from decay.

Built beams and ribs of timber. Trussed beams of timber.

Floors.—Single floors, double floors, framed floors; wall plates, templates. Common joists, strutting joists, trimming joists. Floor boards. Ceiling joists. Precautions to be observed in laying floors, with respect to door and window openings and partition walls.

Partitions.—General remarks Framed without doorway. With ordinary doorway in centre. With side door. Common partition. Brick-nogged partitions.

Timber Roofs.—Flat roof. Pitch of roof. Couple roof. Couple-close roof. Collar beam roof. King bolt roof without struts. King post roof. Queen post roof. Purlins. Rafters.

Stairs.—Dimensions of stairs. Rule for proportion of rise to tread. Method of laying out stairs. *Different forms of stairs :*—Straight, dogged-legged, geometrical. *Parts of wooden stairs :*—Strings, steps. General rules for planning stairs.

Doors and windows.—Ledged doors, ledged and braced doors, panelled doors, glazed doors. Door frames. Fixed sashes. Fanlights. Sashes hung on centres. General arrangements of sliding sashes.

Foundations.

Importance of slight and uniform settlement. Various modes of attaining that object. Action of water on foundations. Various conditions dependent on nature of bearing strata.

Importance of ascertaining the character of bearing strata. Trial pits. Borings.

Dry foundations. Rock. Gravel. Sand. Mixed strata of rocks and clay. Shale. Clay. Expansion of clay when exposed. Bearing stratum underlying soft ground of considerable depth. Crust of good ground overlying soft substratum.

Mechanical construction of foundations. Footings. Planking. Use of sand, concrete and béton.

Land foundations on artificial bottom. Consolidation of soft ground by driving piles. Platforms of fascines, timber or concrete, forming floating foundations.

Foundations on good natural bottom under water. Piled foundations. Timber piling. Cast and wrought iron piling. Iron screw piles. Hollow cast iron cylinders. Brick wells, as employed in India. Sand pump. Solid foundations laid under water. Pierre perdue. Random blocks of béton. Béton laid in caissons lined with tarpaulin. Solid masonry built on the natural bottom by divers. Solid masonry in cribs.

Foundations on sites where the water can be temporarily excluded. Solid masonry sunk in caissons on a bottom dredged out and levelled with béton. The same on a piled bottom. Solid masonry built in a cofferdam.

Arching.

Names of parts—Different forms of arches. Inverted arches.

Brick arches.—Rough brick arches, axed arches, gauged arches.

Arches over openings in wall.—Segmental face arch, semi-circular arch, straight arch.

Stone arches.—Ashlar. Rubble.

Buildings.

Selection of ~~sight~~—Design of foundations and preparation of bed. Thickness of walls. Points to be attended to in building walls. Buttresses. Arches in walls. Floors of various kinds. *Roofs*—Different forms of tresses in wood and iron. *Roof covering.*—Various materials used for this purpose, and mode of applying. Ceilings, chimneys, fire-places. Doors and windows. Drainage and ventilation, lightning-conductors.

Bridges.

Temporary expedients for crossing rivers.—Causeways, temporary bridges, ferry boats, boat and pontoon bridges, rope bridges.

Masonry Bridges.—Details of the various parts in brick and stone, with principles of design.

Wooden Bridges.—Various forms of trusses and details of parts.

Iron and Steel Bridges.—Different forms of girders used, with full details of joints, roadway, &c., and mode of calculating the strength of the various parts. Methods adopted for erecting bridges.

Roads.

Fair-weather roads in districts liable to inundations. Permanent roads. Resistance of vehicles on roads variously paved. Ruling gradients. Staking out the centre line. Formation. Breadth and cross section. Earthwork. Side slopes. Culverts and drains. Road metalling. Paving with stone blocks. Maintenance and repairs. Hill roads. Street paving in towns.

Railways.

Survey and choice of line. Gradients and curves. Resistance of railway trains on a level straight line. On curves and steep gradients.

Formation of roadway. Earthworks. Formation level. Base. Culverts. Regulations about bridges. Level crossings. Fencing. Mile posts. Gradient posts.

Permanent-way of railways. Gauge of railways. Ballast. Timber sleepers. Rails. Chairs. Rail joints, fish joints. Cast-iron sleepers. Wrought-iron sleepers. Cant of rails. Elevation of outer rail on curves. Sidings. Switches and crossings. Turntables.

Railway stations. Design and arrangement. Classification. Terminal stations. Intermediate stations. Selection of site. Details of terminal stations. Approaches, roads and yards. Position of principal buildings. Parallel or side-station system. Transverse or end-station system. Goods stations. Goods yard at small stations. Signals.

Irrigation Works.

Well-irrigation.—Common machinery employed in India for raising water from wells.

Canal irrigation. Inundation canals.—General rules for the selection of best site for head works. Head sluices. Slope of bed.

Permanent canals.—Sources of supply, amount of water required, slope of bed, discharges of canals, section of channel, alignment of canal. Head works—weirs, regulators ; falls, rapids, locks, navigation channels, aqueducts, inlets, level crossings, super-passages.

Distribution of water.—Rajbahas. Modules.

Tank-irrigation.—Site of embankment. Different forms of embankment. Waste weirs. Irrigation sluices.

River inundation and river improvement —General methods in use to improve the course of streams, and to render channels navigable.

3.—ESTIMATING.

General principles of estimating. Rules of mensuration of surfaces and solids.

The student will be exercised in taking out quantities and framing an estimate from working drawings of the following examples :—

A masonry culvert. A portion of road in cutting and embankment. A house. A wooden bridge. An iron bridge. A masonry bridge.

4.—APPLIED MECHANICS.

Definitions.

Elasticity.—Plasticity and rigidity. Stress, its nature and intensity. Tensile, compressive, and shearing stresses. Positive and negative senses of a stress. Stresses of uniform and variable intensities. Ultimate strength. Factor of safety.

Tension.

Simple tension.—Work done in stretching a rod. Thin pipes under internal fluid pressure. Strength of prismatic solids under tensile stress when the resultant of applied forces does not coincide with the axis of the solid Safe tensile co-efficients of various materials.

Compression.

Classification of bars or pillars under compression :—Very short pillars, short pillars, long pillars, very long pillars. Methods of failure of these classes of pillars. Rondolet's, Hodgkinson's and Gordon's formulæ. Euler's formula. Fairbairn's formula for collapsing of tubes under fluid pressure. General remarks on the applicability of the above formulæ. Safe compressive co-efficients of materials usually subjected to a compressive stress : impact, pile driving.

Transverse Strain.

Proof that the stress at each point varies as its distance from the neutral axis.

Determination of the position of the neutral axis.

Determination of the moment of resistance.

Calculation of moments of inertia of ordinary sections used in engineering construction.

Flanged girders :—Approximate and accurate methods.

Proportion of I beams for equal strength.

Beams of uniform strength.

Bending moments and shearing forces.—(Treated graphically and analytically).

Cantilever under single load at free end.

Cantilever under uniformly distributed load.

Cantilever under uniformly distributed load, and one or more detached loads.

Beams supported at the ends and loaded with detached loads at any point.

Beams supported at the ends and loaded uniformly.

Beams supported at the ends and loaded uniformly, and also with one or more detached loads.

Beams supported at the ends and loaded with a single detached moving load

Beams supported at the ends, supporting an uniformly distributed moving load of length less than the span.

Beams supported at the ends, supporting an uniformly distributed moving load of length greater than the span.

Beams supported at the ends and loaded at intermediate points.—Conversion of detached loads into equivalent uniformly distributed load.

Statics of Structures.

Framework loaded at the joints.

Triangular frames.—Diagram of forces for a single triangular frame. Triangular trusses. Cranes and derricks. Sheer-legs and tripods. Effect of the tension of the chain in cranes.

Incomplete frames.—Preliminary ideas. Simple trapezoidal or Queen post truss General case of a funicular polygon under a vertical load. Suspension chains.

Compound frames.—Compound triangular frames for bridge trusses. Roof trusses in timber. Queen truss for large iron roofs. Diagram of forces in general.

Framework girders.—Warren girders under various loads. N trusses. Bowstring girders.

Girders with redundant bars.—Lattice girders, flanged beams.

Deflection of Beams.

Deflection due to the maximum bending moment. General equation of deflection curve. Elementary cases of deflection and slope. Beams propped in the middle. Stiffness of beams. Stiffest beam that can be cut from a circular log.

Shearing.

Distinction between tangential stress and normal stress. Equality of tangential stress on planes at right angles. Tangential stress equivalent to a pair of equal and opposite normal stresses. Web of a beam of I section. Method of computing the intensity of the shearing stress at any point in a bent solid.

Resistance of Prismatic Solids to Simple Torsion.

Explanation of the phenomena of simple torsion.

A circular section, solid or hollow, most favourable form of prismatic solid for resistance to torsion.

Twisting moment. The limiting intensity of the resistance to torsion is that of the shearing stress.

Investigation of the resistance of a circular prism to torsion round its mean fibre.

The strength of axles subject to simple torsion. Values of the limiting intensity of working resistance to simple torsion for different materials.

Diameter of a shaft to transmit a given power.

Blockwork structures.

Stability at a plane joint. Stability of a series of blocks. Centres of pressure or resistance. Line, polygon and curve of pressures. Line of resistance, or polygon of centres of pressures. Moment of stability.

Retaining walls.—Theory of earth pressure. Angle of repose of different soils. Walls supporting a bank of earth with horizontal surface. Surcharged walls. Graphic methods of solution. Determination of the centre of pressure on any joint of a wall supporting a load of earth at its back Maximum intensity of stress at any joint in a retaining wall. Minimum intensity of pressure. Tensile stress at a joint. Effect of cohesion of mortar. Connection between maximum intensity of pressure on foundation course and power of resistance of earth foundation. Methods of equalising intensity of stress on foundation courses.

Masonry arches.—Definitions. Curve of pressures and line of resistance. Conditions of stability. Treatment of the weight of loads of different densities. Graphic process of determining the stability and resistance of any proposed arch by drawing the line of resistance. Depth of key-stone.

Stability and resistance of abutments and piers.—Graphic process of determining the position of resultant pressure on any joint of an abutment. Design of piers.

Stability of foundations of structures in masonry and brickwork.

5.—HYDRAULICS.

1. General Principles.

Velocity and volume of flow. Principle of continuity. Flow in a stream. Steady and varying motion of streams. Fluid acting on piston. Theorem of Bernouilli. Hydraulic head.

2. The flow of Liquids through orifices.

Application of the theorem of Bernouilli. Velocity of flow due to given head. Co-efficient of velocity. Co-efficient of contraction. Co-efficient of discharge. Co-efficient of resistance. Connection between co-efficients of velocity and resistance. Discharge from large rectangular orifices. Borda's mouth-piece. Co-efficient of contraction for Borda's mouth-piece obtained theoretically. Incomplete contraction. Cylindrical and conical mouth-pieces. Flow over notches. Triangular

notches. Velocity of approach. Application of results to measurement of flow in streams. Francis' formula. Discharge of measured quantities of water for irrigation purposes. Italian and Spanish modules. Other forms of apparatus answering the same purpose. Discharge under varying head. Jet pump. Separating weirs.

3. The flow of Liquids in Pipes.

Laws of friction between liquids and surfaces. Froude's and Unwin's experiments. Loss of head due to friction in pipes. Hydraulic mean depth. Variation of co-efficient with velocity and diameter. Darcy's formula. Hydraulic gradient. Ordinary computations of size of pipes and volume of discharge. Loss of head due to bends, elbows, enlargements, &c.

4. Movements of Water in Canals and Rivers.

Mean velocity corresponding to given gradient. Variation of the co-efficient. Velocity at different parts of the section of the stream. Mean velocity in terms of surface and bottom velocity. Ratio of mean to maximum velocity. Forms of section of channel, circular, trapezoidal, egg-profile. Most economical section of channel with given side-slopes. Form of section for a constant velocity with varying discharge.

5. Impulse and Reaction of Water.

Pressure of a jet on a plane surface fixed or moving. Energy communicated to the moving surface and efficiency of jet. Velocity of surface for maximum efficiency. Resultant pressure on curved surface, direct impulse and reaction. Condition to avoid loss by shock when jet is received. Condition for least loss of kinetic energy when jet is discharged.

6. Hydraulic Machines.

Transmission of energy by hydraulic pressure. Power of hydraulic motors. Causes of loss of efficiency in water pressure engines, pumps, accumulators, and water-wheels.

Principle of momentum as applied to rotating machines; turning couple equal to the change of moment of momentum.

Speed for maximum efficiency and losses in reaction wheels.

Most efficient speed of turbines. Angles of moving and guiding vanes. Forms of vanes. Losses of efficiency. Regulation of power of turbines. Estimation and graphical representation of the diminution of total and pressure-head in flow through a turbine.

Centrifugal pumps with radial vanes. Speed for given lift with given efficiency. Utilisation of kinetic energy of whirl. Best form and dimensions of spiral chamber. Whirlpool chamber. Centrifugal pump with backward curved vanes. Losses. Volume discharged.

Efficiency of propellers. Jet propellers Paddle wheel. Screw.

6.—MECHANICAL ENGINEERING.

Description and Construction of the Elementary pieces of Machines.

Shafting. Couplings. Clutches. Friction clutches. Plummer blocks or pedestals. Fixings, wall boxes, brackets, hangers. Footsteps. Bolts and nuts.

Tooth gearing. Spur wheels. Racks. Bevil wheels. Worm gearing. Modes of fixing wheels upon shafts.

Driving belts. Drums and pulleys. Fixing drums and pulleys upon shafts. Rope transmission. Telodynamic transmission.

Cranks. Eccentrics. Cams. Connecting rods.

Valves. Pistons. Stuffing boxes.

Steam Engine.

Fuel and combustion.—Chemical composition and physical properties of the different kinds of fuel. Calorific value of some elements and their compounds. Determination of the calorific value of the different kinds of fuel. Process of combustion. Formation of smoke and flame. Losses by incomplete combustion. Air necessary for combustion. Temperature of combustion. Density of burnt gas. Maintenance of draught, by convection; by artificial means. Transmission of heat from furnace gases. Waste of heat. Methods of stoking. Mechanical stokers.

The Boiler.—Types of boilers. Proportions to provide sufficient grate and heating surfaces. Proportions and methods of construction to provide sufficient strength. Construction to facilitate cleaning and examination. Boiler fittings.

The Steam Engine in general.—Types of engines. Horse-power. Relations between dimensions of cylinder, speed of piston or revolution, and power of engine. The design of the principal details of an engine. Piston, piston rod, connecting rod, crank shaft. The slide valve and eccentric. Link motions. Expansion valves. Zeuner's valve diagrams. The Indicator and Indicator diagrams. The condenser and air pump.

The Locomotive Engine.—Train resistance. Tractive power. Adhesion. Express and coupled engines. General description of ordinary engines. Goods engines. Limit of load on wheels. Fatigue of rails. Description of engines for exceptional circumstances. Engines for steep inclines. Engines for exceptionally heavy trains on moderate inclines. Engines for narrow gauge lines. Double traction. Fairlie engines.

General arrangements of engine and boiler. Reversing. Expansive working. Webb's compound engine. Brakes. Framing. Axle boxes. Springs. Axles. Wheels. Effect of curves on wear of tires. Provisions for reducing the effect of sharp curves. The tender. Ramsbottom's scoop.

Thermodynamics.

Measurement of temperature and quantities of heat. Relations between pressure, temperature, and volume of steam. Total heat of formation of steam.

External work done during evaporation. Relation between heat and work; Joule's equivalent. Internal work of evaporation.

Operation of a non-expansive working engine. Expenditure of heat and steam. Efficiency. Condensation water.

Calculation and graphical representation of the energy exerted by an expanding fluid. Relation between pressure and volume of expanding steam. Indicator diagram. Mean pressure.

Transmission of heat to and from metal of cylinder when steam is used expansively, and consequent limitation of economical ratio of expansion. Expenditure of heat and steam in expansive working engine. Efficiency. Advantage of steam jacket and superheating. Operation of compound engine. Indicator diagrams. Advantages of compound engine.

Efficiency of thermally perfect air engine. Reversibility. Carnot's principle. Maximum efficiency of any heat engine.

7.—SURVEYING.

Lecture Room Course.

(1) Construction of scales—Simple, diagonal, and vernier.

(2) Useful problems in surveying.—To avoid obstacles in the chain line—

1*st*—When the obstacles can be seen over and chained round, but not across.

2*nd*—When it can neither be seen over nor chained across, but can be chained round.

3*rd*—When it can be seen over, but neither chained over nor round.

(3) To find the intersection of two lines meeting in a lake or river, and the distance to the point of meeting.

(4) To find your place in a survey by observation from that position to certain fixed points on the survey—

1*st*—With prismatic compass.

2*nd*—With pocket sextant.

(5) Investigation of various methods of tracing curves—

(*a*) Without angular instruments—

By chords and offsets.

By offsets from a common tangent.

By successive bisection of arcs.

(*b*) With theodolite—

By angles at the circumference when the point of intersection of the tangents to the curve is accessible.

When the point of intersection is inaccessible.

By two theodolites at starting points of curve.

(*c*) Serpentine curves.

(6) Plotting chain survey.
(7) Plotting survey with chain and prismatic compass.
(8) Plotting theodolite traverse by Gale's method.
(9) Plotting level sections.
(10) Computation for the reduction of the base line
(11) Reduction to the centre of angles taken from satellite stations.
(12) Calculation of the sides of the triangles in a trigonometrical survey.
(13) Calculation of the relative vertical heights of the stations as determined by theodolite.
(14) Equalizing areas—
  (*a*) Of irregular polygons.
  (*b*) Of irregular offsets.
(15) Colouring of maps and surveys with the necessary printing of title and drawing of scales.
(16) Colouring of level-sections.
(17) Enlargement or reduction of plans by—
  (*a*) Pantograph.
  (*b*) Squares.
(18) Methods of entering the topographical details, horizontal and vertical styles.
(19) Conventional signs used in surveys and plans.

Practical Astronomy.

(1) Astronomical definitions.
(2) Determination of the true meridian—
  By equal altitudes of a star.
  By maximum elongation of a circumpolar star.
(3) Determination of latitude—
  By meridian altitude of the sun with sextant and artificial horizon.
  By circummeridian altitudes of a star with theodolite.
  By observations on Polaris.
(4) Approximate methods of determining the meridian and latitude without the use of angular instruments.
(5) Construction of horizontal sun-dials and method of graduating dial-plate.
(6) Simple methods of determining the longitude in which the use of the nautical almanac is not required.

Field Work.

First-year Class.

A small survey with chain only.

A more extensive survey (Botanic Gardens) with chain and prismatic compass.

A line of levels about two miles long, the same to be carefully checked.

Ground tracing.

Second-year Class.

A line of levels about one mile long, the same being carefully checked.

A survey, about four square miles in area, by triangulation and traverse (Gale's), the details being filled in by plane-table.

Contouring. Laying out curves. Setting out half widths on side-long ground. Erection of profiles for embankments. Adjustments of instruments. Observations for determining the meridian and latitude.

Third-year Class.

Select a line of railway about five miles long; make a traverse along the same, filling in detailed plan by plane-table. Level over this line, and make the needful cross sections.

8.—DRAWING.

Construction of scales. Geometrical construction. Curves of arches, &c. Descriptive Geometry. Orthographic Projection: Of Planes: Of Solids, under given conditions. Sections of solids. Intersection of solids. Development of solids. Shadows Isometrical Projection. Perspective. Machinery. Topographical drawing.

Work to be executed by students.

1. Printing. 2. Scales. 3. Geometrical Figures. 4. Arches. 5. Problems in Descriptive Geometry. 6. Projections and Intersections of solids. 7. Intersections of Roofs. 8. Elevations, sections and plans of buildings and bridges from copies. 9. Ditto from rough sketches and dimensions. 10. Projections of shadows (simple cases). 11. Free-hand sketches—(*a*) from copies, (*b*) from models. 12. A drawing from actual measurement. 13 Machinery. 14. A simple isometric drawing. 15. A simple perspective drawing. 16. Maps, Sections, &c.

9.—PROJECT.

This will consist of the surveys and levels for a line of canal or railway, about 5 miles long, with cross sections of streams crossed, accompanied by designs for such iron and masonry structures that may be required for the streams or roads that are crossed. The whole to be supplemented by a book of calculations showing how the necessary dimensions have been arrived at.

The drawings that will accompany this project are :—

(1) General plan of country showing adopted line.
(2) Longitudinal section of line.
(3) Design for a masonry bridge.
(4) Design for a plate girder bridge.
(5) Design for an open work bridge, such as a Warren, Lattice, or Bowstring girder.
(6) Such other designs as may be required to complete the project.

The designs will be got up in sufficient detail to enable the bridges, &c., to be ordered without further information.

10.—MATHEMATICS.

Algebra.

Addition, subtraction, multiplication and division of algebraical expressions (including fractions), highest common factor, lowest common multiple, involution, evolution, theory of indices, surds, simple and quadratic equations involving one or more unknown quantities. Theory of quadratic equations and quadratic expressions. Ratio, proportion, variation. Arithmetical, geometrical, and harmonical progressions. Mathematical induction, permutations and combinations. Binomial theorem, exponential theorem.

Trigonometry.

Direction of measurement of straight lines or angles denoted by algebraical sign. Measurement of angles by degrees and circular measure. Definition of the trigonometrical ratios and inverse trigonometrical functions. Investigation of formulæ, including all angles which have the same sine, cosine or tangent. Formulæ expressing the sine, cosine or tangent of the sum or difference of two angles in terms of the trigonometrical ratios of the single angles, with formulæ derived from these. Limiting values of simple trigonometrical functions of an evanescent angle. Sum of a series of sines or cosines of angles in arithmetical progression. Solution of triangles. Properties of triangles. Determination of unknown heights and distances.

Application of Logarithms.

Each candidate will be supplied with a book of mathematical tables, and required to extract all necessary information from the tables. Properties and use of logarithms. Numerical solution of triangles. Easy questions in algebra, trigonometry, mensuration, statics, dynamics, or hydrostatics, involving logarithmic calculation.

Mensuration.

The areas of plane figures, and the application of Simpson's rules. Areas of surfaces. Volumes of solids, including the application of the prismoidal formula.

Plane Geometry (including the Geometry of Conics).

Simple problems in the geometry of the straight line, triangle and circle, treated according to modern methods. The more important properties of the parabola ellipse and hyperbola section of a cone. Text-book, Willson's Elementary Geometry and Conic Sections.

Statics.

The composition and resolution forces, acting in one plane on a particle or rigid body. Moments. Bending moments. Conditions of equilibrium of a particle or rigid body, acted on by forces in one plane. Force diagram of a system of forces in equilibrium. Meaning of virtual work and work done by a force. Applications of the above to the solution of problem (the candidate to be allowed the option of adopting the graphic method of solution). Equilibrium of constrained bodies and the simple machines. Determination of centroids. Friction.

Dynamics.

Kinematics.—Velocity and acceleration, uniform and variable. Angular velocity. Numerical value of velocity or acceleration dependent on units of time and space. Relative velocities and accelerations. Composition and resolution of velocities and accelerations. Formulæ connecting time and space described, velocity and acceleration.

Kinetics.—Newton's laws of motion. Units of mass, force and work. Relation between force, mass moved, and acceleration produced. Attwood's machine. Motion of projectiles in vacuo. Direct impact of bodies. Co-efficient of restitution. Constrained motion of bodies sliding down smooth curves. Formula (without proof) for the time of a small oscillation of a simple pendulum. Uniform motion in a circle. Conical pendulum. The principles of work and energy. Conservation of energy.

Hydrostatics.

Definition of a fluid, a liquid, a gas. Density and specific gravity of a substance and of a mixture of liquids or gases. Pressure at a point. Equality of pressure in all directions in a fluid. Transmission of fluid pressure. The hydrostatic press. Determination of pressure at any point in a homogeneous liquid. Whole pressure on a surface immersed in liquid. Resultant, horizontal and vertical pressure on an immersed surface. Centres of pressure of parallelograms, triangles, circles, or ellipses immersed in any manner in liquid. Conditions of equilibrium of floating bodies. Boyle's and Gay Lussac's laws for gases. The barometer, thermometer, siphon, common pump, air pump, and diving-bell. The atmosphere, pressure at any height in it. Determination of heights by the barometer. Hydrostatic balance. Hydrometers.

Differential Calculus.

Definition of a differential co-efficient. Differential co-efficient of a sum, product, and quotient. Differential co-efficients of simple

functions. Successive differentiation. Leibnitz's theorem. Taylor's theorem Maclaurin's theorem. Expansions of functions. Maxima and minima values of functions of one variable. Differential equation of the tangent and normal to a curve.

Integral Calculus.

Integration, a limiting form of summation. Integration of simple functions by parts and by substitution. Integration of rational fractions. Integration between definite limits of forms which are generally integrable.

CHEMISTRY.

I.—Pure Chemistry.—Physical properties of the metals used in the arts. Alloys. Behaviour of metals on being heated in contact with air. Investigation into the causes of alteration. Oxygen. Nitrogen. Composition of air. Hydrogen. Detonating mixture. Physical properties of non-metals. Allotropic modifications. Rapid, slow, and incomplete combustion. Oxides of carbon, sulphur, phosphorus, arsenic, silicon, boron Metallic oxides. Combination of metals with sulphur. Sulphides of hydrogen and carbon. Preparation and properties of the halogens. Their compounds with hydrogen. Halogen salts. Conversion of oxides, sulphides, and chlorides into each other; roasting. Electrolysis of binary compounds. Displacement of one metal by another in binary compounds. Quantitive analysis of cuprous and cupric oxides. Synthesis and analysis of water. Analysis of the oxides of lead. Laws of definite proportions, of multiple proportions, and of relative atomic masses. Laws of combination by volume. Avogardo's law. Chemical notation. Quantivalence. Anhydrides; hydroxides; acids and bases. The more important oxy-acids. Formation of salts by the interaction of acids and bases. Salts, normal, acids, basic; anhydro-salts. Water of crystallisation and constitution. Formation of salts by the action of acids on oxides and metals. Double decomposition. Principles of alkalimetry and acidimetry. Reduction of oxy salts in solution by metals and by the electric current. Ozone. Hydrogendioxide. Oxides of nitrogen and chlorine; corresponding acids. Oxidising action of nitric, chromic, and permanganic acids; of chlorine, bromine, and hypochlorites. Hydrides of carbon (methane and ethylene), nitrogen, phosphorus, arsenic, antimony. Cyanogen; hydrocyanic acid. General methods of preparing oxides, hydroxides, chlorides, bromides, iodides, sulphates, nitrates, phosphates, carbonates. Solubility of salts; nature of solutions; mutual action of salts in solution; natural waters. The most important sources of the metals used in the arts. Determination of molecular formulas and atomic weights; vapour density; isomorphism; specific heat; depression of freezing point and vapour pressure. The periodic law.

II.—Chemical Energetics: A—Thermo-chemistry.—Object. Methods of investigation. Calorimeters for solutions and combustion. Thermochemical notation (Ostwald's). Thermal units. The fundamental laws of thermodynamics. Cycles. Relation between chemical

reactions and entropy. Allotropy. Hess' principle. Heat of combustion and formation; calculation of heat of formation. Neutralisation; behaviour of the more important mono-, di-, and tri-basic acids. Dissociation; typical examples; connection with temperature and pressure. Thermal changes attending solution and hydration. Exothermal and endothermal reactions. Application of the principles of Thermochemistry to the solution of technical problems.

B.—Photo-chemistry.—Actinometers; Bunsen and Roscoe's experiments. The laws of photo-chemical action. Photo-chemical induction. Contact effects. Assimilation of carbon by plants; storage of solar energy. Action of light on salts of silver, iron, chromium, uranium. Theory of photo-chemical action.

C.—Electro-chemistry.—Faraday's laws. Electro-chemical equivalents. Calculation of E. M. F. of galvanic elements. Differences of potential due to contact of metals and electrolytes. Electrolytic conduction; polarization.

III.—Chemical Technology.—Clorine. Bromine. Iodine. Hydrochloric, sulphuric, nitric acids. Phosphorus. Coal gas. Caustic potash and caustic soda. Nitre. Pearl-ash. Potassium bichromate. Sodium. Common salt. Sodium carbonate: LeBlanc, ammonia process. Borax. Soluble glass. Quicklime. Portland cement. Bleaching powder. Plaster of Paris. Magnesium. Glass and porcelain. Alum. Blanc fixe; zinc white; white and red lead. Silver nitrate.

IV.—Practical Exercises.—Qualitative analysis of solutions containing K, Na, Mg, Ca, Sr, Ba, Zn, Ni, Co, Fe, Al, Cr, Cd, Cu, Hg, Pb, Bi, Sn, Sb, As, Au, Ag. Analysis of chlorides, sulphates, nitrates, nitrites, carbonates, phosphates and silicates. Quantitative analysis, brass, bronze, and bar silver. Determination of sulphur and phosphorus in iron ores. Determination of iron in iron ores and in samples of iron by volumetric analysis. Assaying of iron in the dry way. Determination of gold by Skey's process. Testing of drinking water for ammonia, lead and sodium chloride, colorimetric tests. Analysis of limestones.

PHYSICS.

I. Heat.

Expansion; Ramsden, weight-thermometer; Pierre; Regnault's experiments on the absolute expansion of mercury and the expansion of gases. Charles' law. Principles of thermometry. Temperature as measured by the expansion of solids, liquids, and gases. Mercurial thermometer; air-thermometer. Thermometers for various purposes. Density of solids, liquids, and gases. Absolute temperature. Calorimetry. Specific heats of solids and liquids; method of mixture, Regnault; Bunsen's ice-calorimeter. Specific heat of gases—at constant pressure, Regnault; at constant volume, Rontgen. Dulon and Petit's law; Neumann's law modified by Regnault. Changes of state of aggregation. Regelation. Critical temperature; Andrew's experiments. Measurement of heat of fusion and vaporization. Influence of pressure

on melting and boiling-point. Methods of liquefying gases. Maximum pressure of vapours; Dalton, Regnault; pressure of saturated steam below and above 100° C. Vapour densities; Hoffman's, V. Meyer's methods. Hygrometry; Regnault's hygrometer; psychrometer. Conduction; variable and permanent stages. Simple cases of steady flow across a plate and along a bar; Wiedemann and Franz' experiments. Convection. Joule's determination of the mechanical equivalent of heat.

II. Statical Electricity.

Electrification by friction. Betz' and Ayrton's electroscope. Ice-pail experiment. Induction. Ramsden's machine. Electrophorus. Voss' and Whimhurst's influence machines. Electric work and energy. Indicator diagram of electric work. Exploration of electric field. Potential at any point of the field. Lines and tubes of force. Equipotential surfaces; lines of induction. Method of drawing lines of force and equipotential surface. Measurement of electricity; torsion balance; attracted disc electrometer; quadrant electrometer. Dimensions. Electrostatic units. Capacity. Condensers; electrification of two concentric spheres; Leyden jar, Lodge's hydraulic model. Specific inductive capacity. Absolute measurement of capacity; statical comparison of capacities; measurement of specific inductive capacity; standard air condenser.

III. Current Electricity.

Chemical and thermal methods of producing currents; Daniell, Grove, Bunsen, Leclanche, Meidinger, Smee; thermopile; thermo-electric battery. Pyro-electricity. Classification of bodies as regards transference of electricity. Electrolytic conduction. Electrolysis of fused compounds and of saline solutions. Faraday's laws. The voltameter. Metallic conduction. Ohm's law. Kirchhoff's laws. Units of resistance. Poggendorff's rheochord. Resistance coils. Wheatstone's bridge. Resistance of battery. Resistance of galvanometer; Thomson. Electromotive force. Standard cells—Raoult, Lodge, Latimer Clark. Determination of electromotive force; statical method; Fechner's and Ohm's methods; Poggendorff's compensation method. Relation of electricity to heat; Joule's law; Lenz' experiments. Gaseous conduction. Disruptive discharge. Currents regarded as moving charges; Rowland's experiments. Flow of electricity and flow of electric energy; outlines of Poynting's theory. Phenomena attendant on the starting, stopping, and varying of a current. Oscillating discharges.

IV. Magnetism.

Fundamental experiments. Magnetic field. The earth a magnet magnetic elements; declination theodolite; dip-circle; bifilar magnetometer. Methods of magnetization. Relation of magnetism to electricity. Oersted's experiment. Tangent and sine-galvanometer; Thompson's reflecting galvanometer; Wiedemann's two-coil galvanometer. Electrodynamic experiments; the selenoid. Selenoidal magnets

and magnetic shells. Electromagnets; types. Permeability and methods of measuring it; its relation to temperature and mechanical stress; critical temperature, its relation to other physical properties. Magnetic hysteresis. Magnetic flux, magneto-motive force, reluctance. The law of traction. Induction of currents; Lenz' law. Direction of induced currents specified by reference to lines of magnetic force. Movement of lines of force with change of magnetization. Self-induction. Ruhmkorff's coil. Electromagnetic units. Theories of magnetism.

V. Radiant Energy.

Laws of a vibrating particle. Harmonic vibrations. Transverse and longitudinal waves. Interference of waves travelling in the same and in opposite directions. Stationary waves. Composition of undulations; elliptical, circular, and rectilinear vibrations. Huyghen's principle. Reflection and refraction of thermal, luminous, and electric waves. Velocity of propagation; Foucault's and Fizeau's experiments. Plane, spherical, and parabolic mirrors. Single and double refraction. Prisms and lenses. Minimum deviation. Determination of refractive indices of solids and liquids. Melloni's experiments on radiant heat. Hertz' experiments on electric radiations. Outlines of Maxwell's theory of light. Dispersion. Spectroscope and spectra. Conditions of achromatism. Absorption of ætherial waves: diathermancy and athermancy; coloured bodies.

VI.—Applied Physics.

1. *Heat.*—Pyrometers: Wilson, Siemen's, LeChatelier. The double acting steam-engine. Ice-making machines. Otto's gas-engine. Petroleum engines.

2. *Light.*—The sextant. Photometry; Ayrton's dispersion photometer. Telescopes. Microscopes. The camera obscura; principles of photography.

3. *Electricity and magnetism.*—Electro-metallurgy, Telegraphy and Telephony. Batteries in common use. Signals. Single needle instrument; sounder; Siemen's ink-writer; Siemen's A. B. C; relative merits. Siemen's relay. Line current, local current, double current working, translation. Duplex telegraphy; differential and bridge principle. Overground lines; supports, their preservation; insulators. Faults: in instruments; on line; total, partial, intermittent. Testing; Wheatstone's bridge; localizing faults; loop test. Lightning conductors Terminals, single and multiple points; earth connection, its importance; the conductor proper: material, form; joints; clips and brackets; ridge circuits; incidental connections, gas and water-pipes; space protected; protection of dwelling-houses, magazines, chimneys; periodical inspection and testing; older and modern theories. The telephone and microphone. Electric bells and indicators. Dynamo-electric machinery. S. Thompson's definition of dynamo. The ideal simple dynamo and motor; connection between counter-electromotive force and maximum work. Efficiency. Causes of loss of energy. Types of armatures; armature coils and cores. Field magnets. Pole-pieces. Field magnet coils. Commutators, Collectors,

brushes, brush-holders. Curves of potentials and induction. Reaction of armature and field. Lead of brushes; angle of lead Methods of exciting field magnets. Classification of dynamos. Examples. Dynamos of class I; closed coil armatures: gramme for large currents, Victoria dynamo; open-coil armature: brush. Dynamos of class II: alternate current dynamo. Dynamos of class III. Characteristics.

Transmission of electric energy. Accumulators. Transformers. Air-lines; insulators, testing; modes of attaching the wire; material for wires; joints; Thompson's lightning protector. Underground conduits; the three-wire system, lead covered cables. Comparison with other methods of transmitting energy.

Motors. Reckenzaun, Immisch. Appliances: electric pumping plant electric tramways, telpher lines, electric mining machinery.

Electric lighting. The brush lamp. Incandescent lamps. Electric welding. Electric measurements and measuring apparatus. The volt and Ampère. Ayrton's sulphuric acid voltameter. Calibration of galvanometers. Methods of shielding galvanometers. Proportional galvanometers. Ampère-meters and volt-meters. Ampère-balances. The ballistic galvanometers. Permanent magnet meters: Ayrton's. Spring meters: Siemen's electro-dynamometer, Ayrton's magnifying spring ammeter. Gravity control-meters. Electro-magnetic control-meters. Relative merits; testing for accuracy; calibration by the calorimetric and the voltameter methods. Cardew's voltameter. The Ohm; resistance coils; the shunt-box. Commercial Ohmmeters. The Farad and micra-farad. The Watt.

METALLURGY.

Physical properties of metals; testing machines; influence of impurities on the properties of iron and copper.

Alloys.—Effect of temperature changes on metals and alloys, with special reference to steel; annealing, hardening, tempering.

Fuel. - Classification; manufacture of coke; Wilson's gas producer; water gas; absolute, specific, and pyrometric heating power; assay of coal; Wright's calorimeter.

Materials.– Ores; fluxes; slags; oxidising and reducing agents; calculation of furnace charges.

Furnaces.—Hearths for roasting and refining and liquation; shaft furnaces; iron blast furnace, Rachette, Pilz, cupola, reverberatory furnaces, puddling-furnace, furnaces used in the smelting for copper and tin, cupellation, closed-vessel furnaces, Deville's blast furnace, furnaces used in the reduction of blende and cinnabar and in the manufacture of cement steel, the converter. Means of supplying air chimneys, blowing engines, Cowper's and Whitwell's stoves.

Metallurgical processes.—Classification, outline of typical processes. Blast-furnace process; puddling; Dank's furnace; Seimen's open hearth; Siemen's Martin; Bessemer; basic process; Darby's recarburisation process; tungsten steel, mitis metal The Idria process. Huhner's furnace. Tin smelting. Extraction of zinc by the Belgian and Silesian methods. Heroult's aluminium process. Welsh process of extracting

copper from copper pyrite. Lead smelting, Flintshire Extraction of silver from lead, Parkes, Pattinson, cupellation, concentration of gold in batteries, modern pan amalgamation. Augustin's wet process as practised in America; Plattner's chlorine process. Methods of producing sound castings.

General considerations.—Capital and labour; causes of failure; prices of metals.

GEOLOGY.

Object of geology.—Its relation to other sciences. The doctrine of uniformity; its limits

I. *Astronomical Geology.*—Information obtained from meteorites and by the spectroscope. The nebular theory. Origin of internal heat. Climate in its geological relations; glacial and mild periods; Croll's theory modified by Wallace.

II. *Geognosy.*—The globe and its envelopes. Shape and nature of globe; density; probable internal condition; evidences of pressure and internal heat; isogeothermal surfaces. The age of the earth's crust, Tait's and Wallace's views. Persistence of continental ridges and abysmal depressions. *Petrography.* Microscopic character of rocks. Microscopic elements; their importance for the study of the history of rocks. Microscopic character of quartz, orthoclase, plagioclase, augite, hornblende, calcite. Essential and accessory constituents. Classification of rocks. Microscopic characters and essential constituents of the following rocks: limestone, dolomite, quartzite, flint, jasper, hornstone; amphibolite; gneiss, micaceous and chloritic schists, phyllite; granite; quartzporphyry; syenite, trachyte, phonolite, obsidian, pumice; diorite; diabase, dolerite, plagioclase-basalt; sand and gravel, sandstones, conglomerates, breccias, shale, clay; laterites; tuffs; shell-marl, coral-limestone, chalk, crinoidal limestone; tripolite, flint; guano; peat, lignite, coal, anthracite, graphite, oil-shale, petroleum, asphalt; bog iron ore, clay-ironstone.

III. *Dynamical Geology*—Volcanic phenomena; description of volcanoes—kind, shape, distribution, relation to lines of weak resistance and instability. Theories of vulcanicity. Hot springs. Earthquakes. Secular upheaval and depression. Geological functions of air. Geological functions of water and ice; chemical and mechanical action; denudation and deposition; river valleys; peculiarities of Indian rivers; glacial erosion; formation of lakes. Geological functions of plants and animals; coral islands; Darwin's and Murray's theories.

IV. *Petrogenetic Geology.*—Origin of granite, syenite, diabase, diorite, and basalt. Origin of sedimentary rocks; minerogen, phytogen, and zoogen sedimentary rocks; theories on the origin of coal-beds; origin of laterite. Origin of metamorphic rocks; theories of metamorphism; local and regional metamorphism; origin of rock-cleavage. Ore deposits; origin and classification.

V. *Architectonic Geology.*—Forms of bedding. Surface markings. Concretions. Relative persistence of strata. Overlap. Groups of

strata Joints. Strike and dip; outcrop. Monocline, syncline, anticline. Faults, origin and kinds. Intrusive phase of eruptivity; bosses, sheets, veins and dykes, necks. Interbedded phase of eruptivity; lavas tuffs. Unconformability.

VI. *Palæontological Geology.*— Object. Conditions for the entombment of organic remains. Preservation of organic remains in mineral, masses; fossilization. Uses of fossils in geology.

VII. *Historical Geology.*—Leading principles in stratigraphy. Equivalent strata; absent strata and formations. *Indian Geology.* Peninsular Area. The metamorphic series. The transition series. Lower and Upper Vindhyans; petrology; Vindhyan basin. The Gondwána system; geological position and characters; probable fluviatile origin; relation of Gondwána basins to existing valleys; lower and upper groups; Tálchir—Karhárbari; Barákar, ironstone shales; Rániganj; Rajmahál; the most important coal-fields. The Deccan trap series; area and petrology. Laterite; distribution, age. Post tertiary and recent formations; older river gravels and clays; kankar. Indo-Gangetic plain; upland and alluvial soils; red soil, regur, peat. General outlines of the geology of the Himalayan area.

VIII. *Physiographical Geology.*—Terrestial features due to disturbance of crust; monoclinal, symmetrical, unsymmetrical, reversed flexures; alpine type of mountain structure. Features due to volcanic action; the Deccan trap area. Features due to erosion; Indian examples.

IX *Field Geology.*—Geological surveying; instruments; tracing of boundaries and faults. Sections; how to find direction and amount of dip; Dalton's construction; clinometer. Levelling; surface profile, datum level, bench-marks, methods of geological levelling, Abney's level. Lithology; practical exercises in the identification of Indian rocks.

MINERALOGY.

Province of mineralogy. Its relation to other sciences.

I. Properties of crystals independent of direction.

Density and specific gravity. Methods of determining specific gravities; hydrostatic balance; pycnometer; Jolly's balance; floatation methods.—Thoulet's, Klein's, Retger's solutions. Separation of rock-forming minerals by the floatation method.

II. Physical Crystallography.

Elasticity. Relation of co-efficient of elasticity to direction. Surfaces of elasticity. Method of determining co-efficients of elasticity in crystals. Classification of crystals with reference to elasticity. Physical definition of "crystal."

Cohesion. Cleavage. Fracture. Hardness: Mohs' scale. Corrosion figures; Lavizzari's experiment.

Optical properties of minerals. Kind and degree of lustre. Double refraction and polarization. Nicoll's prism. Classification of crystals

according to their optical properties. Uniaxial and biaxial crystals. Examination of crystals in parallel and convergent polarized light; polarization microscope. Circular polarization. Absorption of light; ideochromatic and allochromatic minerals; pleochroism, Haidinger's dichroscope, microscope with one nicol; distinction between augite and hornblende.

Thermal properties. Good and bad conductors; conductivity of single and double refracting crystals; expansion.

Electrical properties. Good and bad conductors; pyro-, actino-, and piezo-electricity, Hankel's researches.

Magnetic properties. Para- and diamagnetic minerals. Separation of rock-constituents by the electro-magnet

III. Geometrical Crystallography.

Relation of physical properties to geometrical form; arrangement of molecules. Crystalline form; faces. Planes of reference; axes, parameters; indices; symbols. Law of rationality of indices, its independence of temperature. Principles of Miller's, Weiss', Nauman's notation. Fundamental form; its selection Zones; tautozonal faces; zonal axis; law of conservation of zones. Symmetry; planes and axes of symmetry; principal and common planes. Classification of crystals. Fundamental law of physical crystallography. The six crystallographic systems characterized with reference to planes of symmetry. Simple forms and combinations. The holohedral forms of the regular system as modifications of the hexakisoctahedron. Combinations of hexahedron, octahedron, and rhombic dodecahedron. The holodedral forms of the remaining five systems. Closed and open forms; prismatic, tabular and pyramidal habit. Nature of hemihedrism. Tetrahedral, pentagonal, and plagihedral hemihedrism in the regular system. Rhombic resp, sphenoidal, pyramidal, and trapezohedral hemihedrism in the hexagonal and tetragonal systems. Sphenoidal hemihedrism in the rhombic system. Hemihedrism impossible in the monosymmetric and asymmetric systems. The nature of Tetartohedrism. Trapezohedral tetartohedrism in the hexagonal system; quartz. Apparently holohedral forms differ from real ones—loss of symmetry by combination with particular hemihedral forms, corrosion figures, circular polarization. Hemimorphism—tourmaline, hemimorphite. Crystallographic mimicry-leucite, sal-ammonia. Groth's method of deducing hemihedral and tetartohedral from holohedral forms. Isomorphism and heteromorphism. Isomorphous groups of elements. Iso-heteromorphous series of the calcite-arragonite group, of the augite-hornblende group, and of the felspars. Morphotropism and Isogonism. Hemitrophy. Twinning plane, twinning-axis, composition plane. Twins with parallel and non-parallel axes. Contact-twins and penetration twins. Distinctive features of hemitropes. Polysynthetic crystals. Twin striation and combination striation. Crystalline aggregates, druses. Pseudomorphism. Pseudomorphs by incrustation, substitution, and alteration; paramorphs. Measurement of angles; contact and reflecting goniometers; relative merits.

IV. Chemical Mineralogy. Calculation of formula. Groth's classification of minerals. Group tests.

V. Descriptive Mineralogy. A somewhat detailed description of the following minerals—

Elements: diamond, graphite, sulphur, bismuth, copper, silver, gold, platinum. *Sulphides:* pyrite, marcasite, arsenopyrite; leucopyrite; pyrrhotite; galena, chalcosite, sphalerite, argentite, cinnabarite; antimonite; chalcopyrite, bornite.

Sulphosalts: pyrargyrite, proustite, tetrahedrite, stephanite. *Oxides:* cuprite; zinkite; corundum, hematite, menaccanite; spinel, franklinite, magnetite, chromite; quartz, cassiterite, pyrolusite; geothite; limonite. *Oxysalts:* (*a*) carbonates—calcite, dolomite, magnesite, siderite, smithsonite; aragonite, witherite, strontianite, cerussite; azurite; malachite; (*b*) sulphates—anhydrite, barite; gypsum; (*c*) phosphates—apatite; (*d*) silicates—tourmaline; epidote; olivine; calamine; garnet; leucite, nephesite; muscovite, brotite, lithionite; prochlorite, rhipidolite; talc, serpentine; apophyllite stilbite, heulandite; hypersthene pyroxene, amphibol; orthoclase, microcline, albite, indianite, oligoclase-labradorite; kaolinite. *Haloid salts:* sylvite, halite, cerargyrite, fluorite; cryolite.

VI. Practical exercises. Determination of specific gravities. Use of the scale of hardness. Exercises at the polarization microscope. Measurement of angles by the aid of contact and reflecting goniometers. Blowpipe analysis. Identification of Indian minerals by the aid of Brush's 'Manual of Determinative Mineralogy.'

APPENDIX A

Course of Study for the Engineer Department.

	First year.	Second year.	Third year.	Fourth year, Civil Engineers.	Fourth year, Mechanical Engineers.
Mathematics ...	Algebra, Euclid. Trigonometry and Mensuration	Statics, Dynamics, Geometrical Conic Sections.	Analytical Geometry, Differential Calculus, Elements of Integral Calculus.	Integral Calculus, Hydrostatics.	Integral Calculus, Hydrostatics.
Natural Science	Chemistry (or Physics).	Physics (or Chemistry)	Mineralogy ...	Geology and Metallurgy, Practical Chemistry.	Practical Chemistry.
Engineering ...	Field work ...	Building materials brick and stone masonry, earthwork, carpentry, foundations, roads, estimating masonry structures, direct stresses in building materials, surveying.	Construction of walls, floors, and roofs, railroads, irrigation works, arching retaining walls, stresses in roof trusses, estimating iron structures, mechanism, surveying.	Iron bridge construction, transverse stress, deflection, stresses in girder bridges and suspension bridges, torsion, hydraulics, steam engine, architecture, preparation of civil engineering project	Transverse stress, deflection, stresses in girder bridges and suspension bridges, torsion, steam-engine, workshop appliances, machine designs, preparation of mechanical design.
Drawing ...	Printing, geometrical and orthographic projections, scales.	Isometrical, topographical, and free hand drawing.	Perspective, topographical, free-hand, architectural, and machine-drawing.	Mechanical, topographical, and free-hand drawing.	Machine-drawing, free-hand drawing.

ENGINEER DEPARTMENT.

WORKSHOP COURSE.

Workshop hours ... 1 P.M. till 3-30 P.M. daily except Saturdays.

FIRST YEAR.

Carpenters' shop.—A complete course in the use of carpenters' and joiners' tools. The students are required to make ordinary joints, stool, boxes, doors, windows, tables, trusses, and the usual framings required in engineering works. Their proficiency in this branch of their practical training is tested at the end of their first year by a carefully supervised examination, and every student must gain half marks before he can be promoted to a higher class.

SECOND YEAR.

Blacksmiths' and Boiler-makers' shop.—The course in this shop comprises the using and handling of the different tools; laying and managing the fires; drawing down, bending, jumping, welding, splitting, punching, chamfering and tempering. The students are required to make small forgings of tools, bolts, nuts, hooks, shackles, parts of roof trusses, and machines. In the boiler-makers' shop they are familiarised with the use of riveting tools and the process of riveting, and learn to punch and shear correctly with the machines for that purpose. Their proficiency is tested at the end of the year by a carefully supervised examination, and every student must gain half marks before he can be promoted to a higher class.

THIRD YEAR.

Vicemen and Fitters' shop.—The course in this shop consists of chipping, filing, and fitting to enable the students to gain experience in the tools used by this class of workmen, after which they make up various tools required in the Fitters' shop, and assist in ordinary fitting work. Their practical skill in this shop is not tested by examination, but in lieu of this they are required to keep note-books in which they sketch to scale the various details of the common machines in the shops, and are expected to be familiar with the working of all machines in the shop.

ENGINEER DEPARTMENT.

ANNUAL EXAMINATION.

MAY.

ARITHMETIC AND ALGEBRA.

1st and 2nd years.

1. Simplify $1\frac{1}{6}$ of $5\frac{1}{4} + \frac{4\frac{1}{2} - \frac{3}{10}}{1\frac{1}{15}} - \frac{6\frac{3}{4}}{\frac{1}{2}\text{ of }2\frac{2}{3}}$.

2. Add together $32{\cdot}0\dot{1}0\dot{1}\dot{1} + 76{\cdot}0\dot{9}1\dot{4} + 5{\cdot}1\dot{3}7\dot{5} + 98{\cdot}86\dot{3}$, giving the answer as a recurring decimal.

3. A merchant sells tea to a tradesman at a profit of 60%; but the tradesman becoming bankrupt pays only 2*s.* 6*d.* in the £; how much % does the merchant gain or lose?

4. If the discount on a bill of £1,337-3 at $4\frac{3}{5}$% be £162-3, when is the bill due?

5. A can give B 110 yards in 2 miles, and A can give C 120 yards in 5 miles. If B and C run one mile, which will win, and by how much?

6. Express in factors: $x^3 - 8y^3 + z^3 + 6xyz$;
$81x^4 + 36x^2y^2 + 16y^4$; $x^3 - 9x^2 + 26x - 24$.

7. Solve—

(1) $x^2y^2 + 192 = 28xy$.
$x + y = 8$.

(2) $\sqrt{\frac{x}{1-x}} + \sqrt{\frac{1-x}{x}} = 2\frac{1}{6}$.

(3) $x(x-2a) = \frac{8a^4}{x^2-2ax} + 7a^2$.

8. When $x = \frac{3 + 5\sqrt{-1}}{2}$, find the value of $2x^3 + 2x^2 - 7x + 72$; and shew that it will be unaltered if $\frac{3 - 5\sqrt{-1}}{2}$ be substituted for x.

9. If a, b, c, d be in continued proportion, shew that $b + c$ is a mean proportional between $a + b$ and $c + d$.

Find $a : b : c$ having given

$$\frac{b}{a+b} = \frac{a+c-b}{b+c-a} = \frac{a+b+c}{2a+b+2c}.$$

10. Sum the following series:—

(1) $1 \cdot 3, -3 \cdot 1, -7 \cdot 5$, to 10 terms.
(2) $16 \cdot 2, 5 \cdot 4, 1 \cdot 8,$ to 7 „
(3) $1 + 3x + 5x^2 + 7x^3 + 9x^4 +$ to infinity,
x being $\angle$ unity.

11. A letter-lock consists of four rings, each marked with twelve different letters; find in how many ways it is possible to make an unsuccessful attempt to open the lock.

12. Find the first three terms in the expansion of $\frac{(1+3x)^{\frac{1}{2}}}{(1-2x)^{\frac{1}{3}}}$.

Find the coefficient of x^r in the expansion of $(1 + 2x + 3x^2 + 4x^3 +$ to infinity$)^n$, x being $\angle$ unity.

N.B.—The 1st year will omit the second part of questions 9 and 12, and the third part of question 10.

Geometry.

1st and 2nd years.

1. Define segment, arc, sector, tangent, of a circle. What are the medians, centroid, altitudes, orthocentre, of a triangle? What is the angle of a segment?

2. Shew that the interior angles of any polygon together with four right angles are equal to twice as many right angles as the polygon has sides. Hence deduce a formula for the angle of a regular polygon of n sides.

3. Shew that the straight lines which join the middle points of the opposite sides of a quadrilateral bisect one another.

4. Produce a given straight line so that the rectangle contained by the given line and the whole line thus produced may be equal to the square on the part produced.

5. Describe a square that shall be equal to a given rectilineal figure.

6. Shew that the opposite angles of a quadrilateral inscribed in a circle are together equal to two right angles.

7. In equal circles the arcs which subtend equal angles whether at the centres or at the circumferences are equal.

If two chords intersect without a circle they form an angle equal to that subtended at the circumference by the difference of the arcs they cut off.

8. Shew that the sum of the diameters of the inscribed and circumscribed circles of a right-angled triangle is equal to the sum of the sides containing the right angle.

9. Inscribe a regular pentagon in a given circle.

10. Define ratio. When are two magnitudes said to be incommensurable.

If two triangles be equiangular to one another, the sides about the equal angles shall be proportionals, those sides which are opposite to equal angles being homologous.

11. The rectangle contained by the diagonals of a quadrilateral inscribed in a circle is equal to the sum of the two rectangles contained by the opposite sides.

12 Given the base of a triangle and the ratio of the sides, find the locus of the vertex.

N.B.—The 1st year will omit questions 11 and 12.

Mensuration and Trigonometry.

1st and 2nd years.

*N.B.—Questions marked thus * are to be answered by the 2nd year only.*

1. ABCD is a rectangular board $12'' \times 6'' \times 4''$; E, F, G, H are the middle points of AB, BC, CD, DA, respectively. The corners AEH, EBF, FCG, GDH are cut away to half the thickness of the wood. Find the surface of the remainder.

2. Find the diameter of a circle circumscribing a triangle whose sides are given.

3. State Simpson's rule and apply it to find the area of the figure having the following dimensions:—0, 3, 4, 4·6, 4·9, 5, 4·9, 4·6, 4, 3, 0; common distance $\frac{1}{2}$ foot.

4 Prove $\cos(A + B) = \cos A \cos B - \sin A \sin B$, and find $\sin 3A$ in terms of $\sin A$.

5. Trace the changes in the tangent of an angle, as the angle changes from 0 to 2π.

* If $2 \tan\theta + \sec\theta = 4$, prove that $\cos\theta = \frac{2 \pm \sqrt{19}}{10}$.

6. If $A + B + C = 180°$, prove that $2\left\{1 + \sin\frac{A}{2}\sin\frac{B}{2}\sin\frac{C}{2}\right\} = \cos^2\frac{A}{2} + \cos^2\frac{B}{2} + \cos^2\frac{C}{2}$.

7. Express the sine and cosine of half the angle of a triangle in terms of the sides.

8. Find the radius of the escribed circle of a triangle.

* If O is the centre of the circumscribed circle (radius R) and O′ is the centre of the inscribed circle (radius r), prove that $OO' = R\sqrt{-2Rr}$.

9. A and B are two marks on the bank of a straight part of a river 450 yards apart, and P is a mark on the opposite bank. On observing P from A, it is observed that AP makes an angle of 35°26′ with AB, and on observing from B, PB makes an angle of 50°15′ with BA. Find the breadth of the river.

Given Log tan 50°15′ = 10·08004, Log tan 35°26′ = 9·8522.

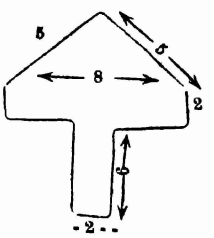
10 * State and prove the exponential theorem.

Statics and Dynamics.

2nd year.

1. Find the magnitude and point of action of the resultant of two parallel forces. Explain the meaning of your answer when the forces are equal but in opposite directions.

2. Find the *C.* of *G.* of a uniform triangular plate Find the *C.* of *G.* of the annexed figure.



3. A body of given weight, and acted on by a force in a given direction, rests on a rough inclined plane. Find the least value of the force that will prevent slipping.

4. *A*, *B*, *C*, are three levers of the first order. The short arm of *A* acts on the ends of the long arm of *B*, and the short arm of *B* on the long arm of *C*. If the ratios of the arms of the three levers are given, find the mechanical advantage of the system.

5. *ABC* is a uniform rod bent at right angles at *B*. *AB* is three times as long as *BC*. It is hung over a smooth horizontal peg at *B*. Find the weight which must be fastened to *C* to make *BC* rest at an angle of 30° to the vertical.

6. State the proposition called "the parallelogram of velocities."

A river is 250 yards wide and runs at the rate of 3 miles an hour. A man who can row at the rate of 3½ miles an hour starts from one side. To what point on the opposite bank must he direct his boat, so that he may go straight across? How long will he take to cross?

7. Prove the formula $s = ut + \frac{1}{2} ft^2$. Explain the meaning of each symbol.

8. A particle projected in any direction, not vertical, and acted on by gravity only, will describe a parabola. Prove this.

If a particle is projected with a velocity of 50 feet per second at an angle of 45°, where will it strike the horizontal plane through the point of projection?

9. A thin inextensible string passes over a fixed light pulley, and has a weight of 2 lbs. at one end and $\frac{1}{2}$ lb. at the other. How far will the heavier weight fall in 2 seconds?

10. Prove that if a particle moves with a velocity v in a circle of radius r, the acceleration is directed to the centre and is $= \frac{v^2}{r}$.

Shew that the acceleration of a body at the equator due to the rotation of the earth is nearly $\frac{1}{290}$th of the acceleration of gravity at the same place. Take radius of the earth = 4,000 miles.

ENGINEERING.

2nd year.

1. Mention what natural Indian stones you would consider it advisable to use for the following purposes, and state where you would procure them if required in Calcutta:—(i) Flooring a public office; (ii) for cornices and ornamental work on a building; (iii) for heavy masonry dams.

2. In quarrying a sedimentary rock, what instructions would you lay down regarding the blasting operations you would allow to be carried on?

3. State the components of a good brick earth, and their proportions, without using the terms alumina and silica. A sample of earth contains 50 per cent. of clay: is this suitable for brick burning? If not, would you add more clay or more sand?

4. What is Garlick's patent stone composed of, and how is it laid for flooring? In connection with the floor recently laid in the new model room, what special precautions appear necessary?

5. Distinguish between the methods adopted for seasoning and those in use for preserving timber from the attacks of insects.

6. Describe the general appearance of a fractured surface of No. 1 Bessemer pig-iron.

What do you understand by mottled pig-iron? Would you class this iron as forge or foundry pig?

7. In a cupola furnace why is lime added? What would happen if lime were added in excess?

8. What are the main points of economy in trench kilns for brick burning? Under what conditions would it not be economical to erect trench kilns?

9. Give any practical tests you would adopt for ascertaining the quality of a cask of Portland cement. (You are not supposed to have any chemicals, nor a testing machine at your disposal.)

10. Explain how Bidder's earthwork tables are formed, and give the numbers which would be found at the intersection of the columns marked 2′ and 8′.

If these are the heights at two points of an embankment 500 feet long with side slopes 1 : 1, and top width 50 feet, find the cubic contents.

Estimating.

2nd year.

Canal Bridge.

Take out the quantities of—

(*a*) Arch masonry, (*b*) Foundation masonry, (*c*) Superstructure masonry.

Surveying.

2nd year.

1. A light is 200 feet above sea-level; at what distance in miles will it be visible from a ship 18 feet above the sea, taking refraction into account?

2. The centre lines of a railway meet at an angle of 114°23′, which angle is to be filled in by a curve of ¼ mile radius; calculate (*a*) length of curve in feet, (*b*) length of tangent in feet, (*c*) angle of circumference for 100′ chord. Natural tangent of 32°48′30″ = ·6446619.

3. When the centre lines meet in the middle of a river, how is the angle of intersection found?

Calculate the radius in feet of a 4° curve. Natural sine of 2° = ·034899.

4. A primary scale is divided into inches, tenths, and half-tenths; design a vernier to read $\frac{1}{500}$th of an inch.

5. Construct a diagonal scale of 7 miles to an inch, to show miles and furlongs. What is the R.F. of this scale?

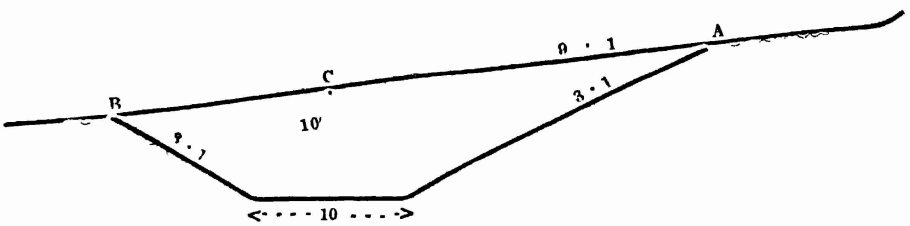
6. How do you ascertain whether the horizontal wire of a dumpy-level is in adjustment? If found to be out of adjustment, how do you correct the error?

7. After measuring 3147 feet with a 100′ chain, you discover that the chain is 2″ too long. What is the true length of the line?

8. Mention an objection to the sextant as a surveying instrument, and prove that the angle it registers is half that between the observed objects.

9. A is a point in the bed of the completed portion of a canal excavation, and B, C, D are points on the natural ground surface in the centre line of canal, distant respectively 120, 220, and 400 feet from A and towards the outfall. A level having been set up gives the following readings on the staff:—At A 13·41 ft., at B 9·36 ft., at C 6·13 ft, at D 2·49 ft. Find the depths to be excavated at B, C, and D, supposing the canal bed to have a fall of 18″ a mile.

10. The figure represents the cross section of a cutting where the depth is 10′, width of base 10′, side slopes 3 : 1, and transverse, or side-long slope of ground 9 : 1; calculate half widths CA and CB measured along the sloping surface.



1st year.

1. Under what circumstances can the position of a point, with reference to two other points, be said to be known? Two stations, A and B, are 1,000 feet apart: A is due north of B. The distance of A is 800 feet from where you are situated, and bears 87°30′ from you. Show your position on a scale of 200′ = 1″, and mark the distance you are from B.

2. A map is on a scale of 220′ = 1 inch. To this scale draw a rectangular field of ten acres, the length being nine times the breadth.

3. Plot the following field and find its area in acres: A to B (go east), 340 feet; B to C, 680 feet (go south-west); C to A, 520 feet; scale 200′ = 1 inch.

4. Describe how you would test the accuracy of a chain for ordinary work in a limited area. What precautions are necessary in measuring a line with a chain?

5. A level in permanent adjustment is erected, and the bubble is also brought perfectly level. Before taking a reading what further adjustments are necessary, and how would you make them?

6. Describe a prismatic compass, and make a drawing of the graduated rim subdivided to read to 15 minutes; show a length of 5°. What external causes affect the reading of a compass?

7. Draw up an ordinary level book in proper form. Enter ten imaginary readings representing a circuit of levels Cast up the book and show that there is an error in your work of — ·02 when closing. R. L. of starting point = 102·74.

8. A, B, C, D are four stations no two of which are in the same straight line. If their positions are to be determined by a chain only, what lines must be measured (1) to give the positions of these points, (2) to check the work.

9. In levelling what do you mean by the errors of curvature and refraction? How can these be avoided?

10. Explain how you would proceed to ascertain if a level was in adjustment before using it.

Drawing.

1*st year*.

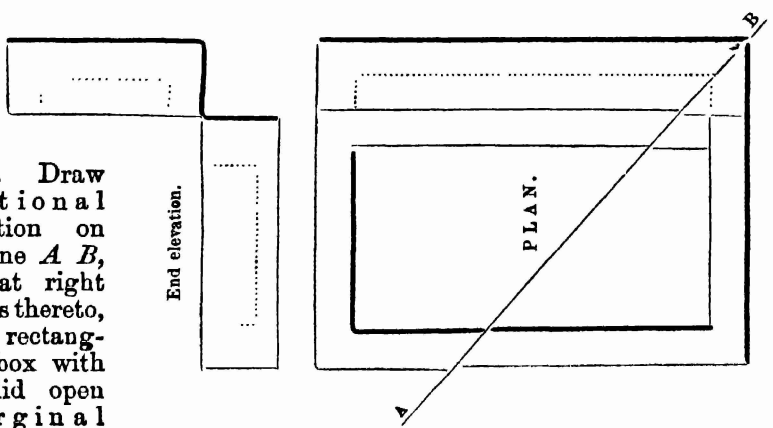
1. On a base 3 inches long construct a triangle whose altitude is 2 inches and vertical angle 30°.

2. Construct geometrically—(*a*) a square which shall contain 6 square inches;
(*b*) a regular pentagon of $1\frac{1}{4}$ inch side.

3. (*a*) What is meant by the representative fraction of a scale?
(*b*) Construct a simple scale of feet and inches, $R\text{-}F = \frac{1}{3\,1\,6}$.
(*c*) A scale is attached to a certain map; and a line 2,000 feet long measures 15 inches on the scale: construct the corresponding diagonal scale of yards.

4. Draw the projections of a prism on a square base of 1 inch side and height 2 inches, when resting on one of the sides of its base, its two parallel faces being inclined at an angle of 45° to the horizontal plane, and the plane of its axis is inclined at an angle of 60° to the vertical plane.

5. Draw sectional elevation on the line *A B*, and at right angles thereto, of a rectangular box with the lid open (marginal figures).



6. The projections of a point being given, draw a plane which shall pass through the point and shall have its traces parallel to the ground line and at equal distance from it.

2nd year.

1. Print in vertical block type, 0·4 inch high, the words "Engineer Department" in pencil only.

2. Draw a scale of 3 inches to a mile to read multiples of 10 yards.

3. In the middle of a square 2″ in the side, construct geometrically another square which shall contain one-third of the area of the original square.

4. A square prism having a base one inch in the side, and a height of 2 inches, is made to balance on one of its points, and then swung round till the plane of its axis makes an angle of 45° with the ground line. Draw its elevation in this position.

5. Explain and illustrate by a diagram the principle of isometrical projection. Draw the isometric scale.

6. Draw the horizontal and vertical projections of a line—

(*a*) Inclined 30° to the horizontal plane and in a plane parallel to the vertical plane.

(*b*) Inclined 30° to the horizontal plane and in a plane inclined 30° to the vertical plane.

(*c*) Inclined to the horizontal plane at an angle of 45°, and in a plane inclined 45° to both horizontal and vertical planes.

7. Draw the isometric of a simple wooden box about 4″ long, having its lid thrown back at an angle of 95°. Assign dimensions to the various parts.

8. On a plane whose traces are inclined to both horizontal and vertical planes, draw the projections of a line inclined at any given angle to the horizontal plane.

Chemistry.

2nd year.

1. How would you prove that atmospheric air is essentially a mixture of oxygen, nitrogen, carbon dioxide, and aqueous vapour?

2. How much manganese dioxide, and a 30 per cent. solution of hydrochloric acid are theoretically required to prepare 10 litres of chlorine measured at 27°C. and 756 mm. pressure?

3. Find the percentage composition of silver bromide, ferric-hydroxide, and potassium chlorate.

4. How is carbon bisulphide prepared on a manufacturing scale?

5. State the different ways in which sulphides are obtained from their elements or from other compounds.

6. Write down the formulæ of the iodides, sulphates, orthophosphates, and oxides of the following metals:—potassium, ferrosum, calcium, ferricum, copper, aluminium, silver, magnesium, sodium, lead.

7. In what different ways may copper be extracted from cupric sulphate?

8. Describe experiments illustrating the different methods by which oxides can be converted into chlorides.

9. Define the terms normal, acid, and basic salt, and give three examples of each; also give examples of normal salts having acid, alkaline, or neutral reactions.

Physics.

1st and 2nd years.

Given—1 foot = 30·48 cm. 1 lb. = 453·6 gm.

Absolute refractive indices—air = 1·00029, water = 1·336, flint-glass = 1·6, Canada balsam = 1·540, calc-spar = 1·654, carbon bisulphide = 1·678.

Minimum pressure of aqueous vapour at 30°C. = 31·55 mm.

1. Write down the dimensional formulæ of density, velocity, acceleration, force, kinetic energy. Forbes found the conductivity of a bar of iron to be 0·00724, the units being the foot, the minute, the degree of any scale, and the foot-degree of heat: what was the conductivity of the bar in C. G. S. units. Referring to this example, explain what is meant by the term 'change-ratio.'

2. What is the value in ergs of a foot-pound at a place at latitude 22°30′ and 25 feet above mean sea-level? What is the value in ergs of a foot-pound at a place where g = 32·1 ft.?

3. Describe any one of the methods adopted by Regnault to determine the coefficient of expansion of air; also point out the errors involved in Gay-Lussac's method.

4. What is the weight of the aqueous vapour contained in 100 litres of moist air at 30°C. and 750 mm. pressure, the humidity being 50 %? If this quantity of vapour was formed at 30°C., how much heat was absorbed by it during its formation?

5. Sketch and describe Coulomb's torsion balance as used in electrical experiments, and find an accurate formula which enables you to reduce the observations made.

6. Describe the Kew dip-circle. What methods must be adopted to eliminate the different sources of error?

7. How was the velocity of light determined by Foucault? What is its approximate value in C. G. S. units?

8. Find the critical angle between calc-spar and Canada balsam, between carbon bisulphide and water, and between water and air. Find

the relative index of refraction between air and flint-glass. The critical angle between benzene and air is 42°, what is the absolute index of refraction of benzene.

9. Reproduce Stall's proof for minimum deviation.

10. What is a prism in optics? The path of a ray of light lies in a principal section of a prism of flint-glass, with a refracting angle of 60°, angle of incidence 15°. Trace the path of the ray of light through the prism.

ENGINEER DEPARTMENT.

FIRST EXAMINATION IN ENGINEERING, 1891.

ARITHMETIC AND ALGEBRA.

Examiner—MR. C. LITTLE, M.A.

Find the value of $\frac{6{\cdot}757}{2{\cdot}17\dot{4}\dot{2}} \times \frac{\cdot\dot{2}\dot{5}\dot{9}}{2{\cdot}78}$ of 12*s.* and $9\frac{3}{4}d.$ correct to the fourth decimal place in farthings.

Simplify $\frac{1 + 2\frac{1}{2} + 3\frac{1}{3}}{\frac{1}{2\frac{1}{3}} + \frac{2}{2\frac{1}{3}} + \frac{3}{3\frac{1}{3}}} \times \frac{55\frac{3}{3} \div 11}{1\frac{3}{11} \text{ of } 13\frac{1}{3}}$.

2. A merchant purchases goods at 71 rupees 8 annas à maund; at what price must he sell to gain $12\frac{1}{2}$ per cent. and allow $2\frac{1}{2}$ per cent. discount to the purchaser?

3. There are two casks A and B, each containing 8 gallons of two fluids: a gallon is taken out of each and put into the other, which operation is repeated four times; how much of the original fluid of A is there remaining in A?

4. The area of a lake which supplies with water a town having a population of 300,000 is 10 sq. miles. Supposing that on an average each person requires 7 gallons of water a day, how much depression will the surface of the lake undergo by one day's supply of water to the town?

Volume of one gallon = 277·274 inches.

Supposing the mean depth of the fall of rain throughout the year to be 26·5 inches, and the lake to be fed (exclusive of the rain which falls on its own surface) by ·75 of the quantity which falls over the surrounding country to the extent of 12 square miles: and also that the amount of evaporation throughout the year is 15·32 inches; how many towns each in population equal to the one above mentioned would the lake supply without its depth diminishing?

5. Simplify—

(1) $\frac{x^3 + 3ax^2 + 3a^2x + a^3}{x^6 - 3a^2x^4 + 3a^4x^2 - a^6}$.

(2) $(ab + ac + bc)(a + b + c) - \{bc(b + c) + ca(a + c) + ab(a + b)\}$.

6. Solve the equations—

(1) $\frac{x-a}{x-b}+\frac{x-b}{x-a}=\frac{a}{b}+\frac{b}{a}$.

(2) $\sqrt{x}+\sqrt{x+7}+2\sqrt{x^2+7x}=35-2x$

(3) $\left.\begin{array}{l} x+y=35 \\ \sqrt[3]{x}+\sqrt{y}=5 \end{array}\right\}$

7. Show how to insert two Harmonical Means between a and b.

If $\frac{(s-b)(s-c)}{bc}, \frac{(s-c)(s-a)}{ac}, \frac{(s-a)(s-b)}{ab}$ be in Arithmetical Progression, prove that $s-a$, $s-b$, and $s-c$ are in Harmonical Progression.

8. Find the number of combinations of n things taken r at a time; and if ${}^{n}\mathrm{C}_{r}$ be the number, prove that

$$ {}^{n+1}\mathrm{C}_{r} = {}^{n}\mathrm{C}_{r} + {}^{n}\mathrm{C}_{r-1}. $$

9. Prove that the coefficient of x^{2n} in the expansion of $\frac{(1-2x)^3}{(1-3x^2)^4}$ is $3^{n-1}.\ \frac{(n+1)(n+2)(5n+3)}{2}$.

10. Obtain the multiplier by which a system of logarithms to one base may be transformed to their equivalent logarithms to another base.

Prove that the Napierean logarithm of

$$ (1+x)^{\frac{1+x}{2}}(1-x)^{\frac{1-x}{2}} = \frac{x^2}{1.2}+\frac{x^4}{3.4}+\frac{x^6}{5.6}\cdots\cdots\ \ldots\ldots $$

11. Having given that $\log_{10}5 = 4{\cdot}6989700$, and $\log_{10}7 = 0{\cdot}8450980$: find $\log_{25}\sqrt{\frac{8}{343}}$ and $\log_{1000}\frac{1}{\sqrt{2}}$.

Given $\left.\begin{array}{l} \log 78549 = 4{\cdot}8951407 \\ \log 78548 = 4{\cdot}8951351 \end{array}\right\}$ find $\log {\cdot}007854876$.

Plane Geometry and Geometrical Conics.

Examiner—Mr. C. Little, M.A.

1. If two triangles have two sides of the one equal to two sides of the other each to each, but the angle contained by the two sides of the one greater than the angle contained by the corresponding sides of the other: prove that the base of that which has the greater angle is greater than the base of the other.

Construct a triangle, having given the base, one of the angles at the base and the sum of the sides.

2. Divide a given straight line into two parts so that the rectangle contained by the whole and one of the parts may be equal to the square on the other part.

Prove that in Euclid's figure there are other lines besides the given line divided according to the proposition.

3. If a straight line touch a circle and from the point of contact a straight line be drawn cutting the circle, the angles which this line makes with the line touching the circle shall be equal to the angles which are in the alternate segments of the circle.

ACB is an isosceles triangle of which AB is the base: CDE is a right line meeting the base in D and the circumscribing circle in E. Prove that AC is a tangent to the circle passing through the points A, D, E.

4. Inscribe a circle in a given regular pentagon.

5. Parallelograms, which are equiangular to one another, have to one another the ratio which is compounded of the ratios of their sides.

ABC, DEF are triangles having the angle A equal to the angle D: and AB is equal to DF, shew that the areas of the triangles are as AC to DE.

6. The rectangle contained by the diagonals of a quadrilateral figure inscribed in a circle is equal to the sum of the two rectangles contained by the opposite sides.

ABCD is a quadrilateral inscribed in a circle and BD bisects the angle ABC: if the points A and C are fixed in the circumference of the circle and B is variable in position, shew that the sum of AB and BC has a constant ratio to BD.

7. If from a point O a pair of tangents OQ, OQ′ be drawn to a parabola and OV be drawn parallel to the axis meeting the parabola in P and QQ′ in V, prove that the tangent at P is parallel to QQ′ and OV is bisected in P.

If QD be drawn at right angles to the diameter PV, prove that $QD^2 = 4AS.\ PV$.

8. If PN be the ordinate of any point P on an ellipse, prove that

$$PN^2 : AN.A'N :: BC^2 : AC^2$$

If TP, TQ, two tangents to an ellipse, meet any third tangent in p, q the angle between the focal radii to p, q is equal to half the angle between the focal radii to P, Q.

9. Define a hyperbola, and prove that S′P—SP is constant.

Given an asymptote, directrix and a point, construct the hyperbola.

10. Through any two points Q and Q′ of an hyperbola a line RQ Q′R′ is drawn meeting the asymptotes in R and R′, prove that RQ=R′Q.′

Trigonometry and Mensuration.

Examiner—Mr. C. Little, M.A.

1. Explain the different methods that are usually adopted for the measurement of angles, and compare the values of the units of measurement.

One of the angles of a quadrilateral is 60°, another is 50 grades, and a third is equal to three-fourths of two right angles: express all the angles in degrees.

2. Express the co-tangent in terms of the other trigonometrical ratios.

Find one angle which satisfies each of the following equations.

(1) $\cos^2\theta + 2\sin^2\theta - \frac{5}{2}\sin\theta = 0$

(2) $\cot^2\theta - \tan^2\theta = 2\sec\theta\,\operatorname{cosec}\theta$

3. Find an expression which includes all angles having a given sine.

Write down the general expressions for angles satisfying the equations in the previous question.

4. Prove the following identities—

$$\tan(A-B) = \frac{\tan A - \tan B}{1+\tan A\tan B}.$$

$$\cos A - \cos B = 2\sin\frac{B-A}{2}\sin\frac{B+A}{2}.$$

If $\alpha + \beta + \gamma = \frac{\pi}{2}$, prove that

$$\frac{\left(1-\tan\frac{\alpha}{2}\right)\left(1-\tan\frac{\beta}{2}\right)\left(1-\tan\frac{\gamma}{2}\right)}{\left(1+\tan\frac{\alpha}{2}\right)\left(1+\tan\frac{\beta}{2}\right)\left(1+\tan\frac{\gamma}{2}\right)} = \frac{\sin\alpha+\sin B+\sin\gamma-1}{\cos\alpha+\cos\beta+\cos\gamma}.$$

5. Prove that $2\sin\frac{A}{2} = \pm\sqrt{1+\sin A} \pm \sqrt{1-\sin A}$, and shew how the ambiguity as to sign is removed.

If $A = 200°$ prove that both signs in the above expression are $+$: and if A lies between 270° and 360° the following relation obtains

$$2\sin\frac{A}{2} = \sqrt{1-\sin A} - \sqrt{1+\sin A}.$$

6. Prove the following relations for the sides and angles of a triangle.

$$\frac{\sin A}{a} = \frac{\sin B}{b} = \frac{\sin C}{c}: \quad \tan\tfrac{1}{2}(B-C) = \frac{b-c}{b+c}\cot\frac{A}{2}.$$

$$\sin A = \frac{2}{bc}\sqrt{s(s-a)(s-b)(s-c)}$$

The sides $a\,b\,c$ of a triangle are in Arithmetical Progression: shew that the area is equal to

$$\frac{b}{4}\sqrt{3(3b-2a)(2a-b)}.$$

7. Explain what is meant by the ambiguous case in the solution of triangles, and under what circumstances the ambiguity may not be expected to occur.

If $a = 25$, $c = 24$ and $C = 65° 59'$, find A, B and the greater value of b, having given

log 2·5 = ·3979400	L sin 65° 59′ = 9·9606739
log 2·4 = ·3802112	L sin 72° 4′ = 9·9783702
log 1·755 = ·2442771	L sin 72° 5′ = 9·9784111
log 1·756 = ·2445245	L sin 41° 56′ 10″ = 9·8249725
	L sin 41° 56′ 26″ = 9·8249959

8. A and B are two positions on opposite sides of a mountain: C is a point visible from A and B, AC and BC are 10 miles and 8 miles respectively, and the angle BCA is 60°. Prove that the distance between A and B is 9·165 miles: and if the angle of elevation of C at A is 8° and at B is 2° 48′ 24″ shew that the height of A above B is one mile very nearly.

sin 8° = ·1391731, sin 2° 48′ 24″ = ·0489664.

9. State the rule for finding the volume of a wedge.

The edge of the wedge is 15 inches; the length of the base is 24 inches and the breadth 7 inches: the height is 22 inches. The wedge is divided into a pyramid and a prism by a plane through one end of the edge parallel to the triangular face at the other end: find the volume of each part.

10. A circular ring whose mean diameter is 18 inches weighs 4033½ oz. Find the radius of the transverse circular section if 240 cubic inches of the substance of which it is made weigh 1000 oz.

11. If a right circular cone be divided into three portions by two planes parallel to the base trisecting the axis, compare the three volumes into which it is divided.

Statics and Dynamics.

Examiner—Mr. C. Little, m.a.

1. State and prove the triangle of forces.

If three forces be represented by the sides of a triangle taken in order, shew that they are equivalent to a couple.

2. Prove that the moment of the resultant of a system of forces in one plane about any point in the plane is equal to the sum of the moments of the forces of the system about that point.

Four straight lines representing forces form the sides of a quadrilateral figure ABCD; three acting in the directions AB, BC, CD, and the fourth acting from A to D. Shew that their resultant is parallel to AD and find its distance from AD by a geometrical construction.

3. A string is fastened to two points A, B and has equal weights attached at C, D, trisecting the string: CD is horizontal, and AC, BD inclined at angles a to the horizon. Find the tensions in AC, CD.

4. Find the centre of gravity of a triangular pyramid, and show that it coincides with the C. G. of four equal particles at the corners of the pyramid.

ABCD is a tetrahedron and a plane CDE passing through the edge CD cuts AB in E. Prove that the line joining the centres of gravity of the tetrahedrons ABCD and AECD is parallel to AB.

5. In the system of pulleys, in which each rope has one end fixed, passes round a pulley and is fastened to the preceding one, prove that

$$W = 2^n P - (w_n + 2w_{n-1} + 2^2 w_{n-2} + \ldots \ldots 2^{n-1} w_1)$$

where W is the weight, P the power and w_1 w_2, &c., the weights of the pulleys.

If the distance of the highest pulley from the fixed end of the rope which passes round it be 16 feet, and the whole height through which the weight can be raised be one foot : find the number of pulleys their size being neglected.

6. A ladder rests with one end against a smooth wall, and is prevented from sliding by the roughness of the ground. Shew that a man weighing as much as the ladder cannot ascend to the top of the ladder without causing it to slip if its inclination to the vertical exceeds $\tan^{-1} \frac{4\mu}{3}$.

If the ascent be possible shew that three times as much friction will be called into play when he is at the top as when he is at the bottom.

7. A particle starts with velocity u under an acceleration f, find the space passed over in time t.

A ball is projected vertically upwards with a given velocity, and when it has attained half its greatest altitude, another ball is projected vertically upwards with the same velocity from the same point. Determine when and where they will meet.

8. Prove that the path of a projectile is a parabola.

From a point on a hill whose inclination is 30°, one projectile is projected up the hill and the other down with equal velocities : the direction of projection in each case being inclined to the horizon at 45°. Show that the range of one projectile is nearly $3\frac{1}{4}$ times the range of the other.

9. Two masses m and m' are connected by a string passing over a smooth pulley : find the tension of the string and the acceleration of either mass. Also prove that the acceleration of their common centre of gravity is $g \left(\frac{m - m'}{m + m'}\right)^2$.

10. Find the velocity at any time of a particle slipping down a given smooth plane curve under the action of gravity.

11. If trains travel generally at 30 miles an hour, find how much the outer rail should be raised on a curve of half a mile radius, the gauge being 4 feet, so that there shall be no side thrust on the flange.

Analytical Geometry.

Examiner—Mr. C. Little, M.A.

1. Find the condition that three straight lines intersect in a point.

A straight line passes through the point (1, — 2) and makes an angle of 60° with the line $5y - 6x + 7 = 0$; find its equation.

2. Find the equation for determining the abscissa of a point in the straight line of which the equation is $\frac{x}{a} + \frac{y}{b} = 1$, whose distance from a given point (α, β) shall be equal to a given straight line c. Shew that there are in general two such points, and that in the particular case in which these two points coincide

$$c^2 (a^2 + b^2) = (a\beta + ba - ab)^2.$$

3. Find the co-ordinates of a point which divides in a given ratio the straight line joining two given points.

The straight line joining the points (3, 1) and (4, 2) is trisected by the circle $x^2 + y^2 + bx + cy = 0$, find the values of b and c.

4. Find the equation of a circle referred to any rectangular axes.

Chords of a circle subtend a right angle at a given fixed point, find the locus of the feet of the perpendiculars drawn from the fixed point to these chords. The equation of the circle referred to the fixed point as origin being $x^2 + y^2 + 2ax + 2by + c = 0$, find the equation of the locus in the form $2(x^2 + y^2) + 2ax + 2by + c = 0$.

5. Find the equation of the polar of the point (h, k) for the parabola $y^2 - 4ax = 0$; and prove that if the polar of (h, k) passes through the point (h', k') the polar of (h', k') passes through (h, k).

Prove that the polar of any point on the parabola $y^2 - 4ax = 0$ for the parabola $x^2 + 4ay = 0$ touches the curve $xy = 2a^2$.

6. PQ, PR are any two chords of a parabola: PQ meets the diameter through R in the point F, and PR meets the diameter through Q in E: prove that EF is parallel to the tangent at P.

7. If a pair of conjugate diameters in the ellipse $\frac{x^2}{a^2} + \frac{y^2}{b^2} - 1 = 0$ make with the axis of x angles whose tangents are m, m', prove that $mm' = -\frac{b^2}{a^2}$.

Normals at P and D the extremities of semi-conjugate diameters meet at K: find the equation of KC and prove that it is perpendicular to PD.

8. If tangents be drawn from different points of an ellipse of lengths equal to n times the semi-conjugate diameter at each point: then the locus of their extremities will be a concentric ellipse with semi-axes equal to $a\sqrt{n^2 + 1}$, $b\sqrt{n^2 + 1}$.

9. Define an asymptote and find the equations of the asymptotes of the hyperbola $\frac{x^2}{a^2} - \frac{y^2}{b^2} - 1 = 0$.

Shew that the line $x = 0$ is an asymptote of the hyperbola $2xy + 3x^2 + 4x - 9 = 0$, and find the equation of the other.

10 If any chord AP through the vertex of a hyperbola be divided in Q so that AQ : QP : : AC^2 : BC^2, and QN be drawn to the foot of the ordinate PN. prove that a straight line drawn at right angles to QN from Q cuts the transverse axis in the same ratio.

GEODESY.

Examiner—MR. G. C. STAWELL.

1. What is the representative fraction of a scale?

Construct a scale whose representative fraction is $\frac{1}{9951}$ showing poles and furlongs.

2. What is meant by a comparative scale?

Construct a comparative scale to scale in question 1 showing metres, decametres up to 15 hectometres (a metre may be taken as 39·37079 inches).

3. Describe briefly but clearly the principle of the vernier. Draw part of the limb of a six-inch theodolite with the vernier set to read 20° 12′ 20″.

4. How is a chain tested? A chain is found to be ½ inch too short; what is the true distance in a measured length of 1,215 links?

5. Explain how you would proceed to take levels over a line of country showing ground levels at every 200 feet. Give a specimen of the field book you would keep and show how you would check the correctness of your levels and calculations. The level of the first station may be taken at 100 + datum.

6. What is a contour?

It is required to drain a low lying piece of ground and to enable this to be done contours are required. Explain briefly what surveys are necessary, and how any contour line would be run. What checks would you take?

7. What are the permanent adjustments of a theodolite and how are they made?

8. Describe a plane table and how it is used.

9. How would you set out a curve with a chain by chords and offsets? Using a 100 foot chain, what would be the length of the offsets for a curve of 5 chains radius?

10. Describe Gale's traverse system.

MATERIALS OF CONSTRUCTION.

Examiner—MR. W. B. GWYTHER.

Candidates are not required to answer more than six question, *viz.*, the first five, and any one of the remaining three.

1. How are building stones usually classed? Give an example of each class, and state roughly the physical and chemical differences between them.

What is Garlick's stone, how and where is it made, and what do you know of its use?

2. What is the composition of a good brick earth? State the changes that occur in a brick during the process of burning, and describe how this process is carried on in Bull's system. Specify a first class brick.

3. What do you understand by the terms 'aggregate' and 'matrix' as applied to mortars and concretes? In what forms and proportions do they occur in ordinary mortar, cement concrete, and sand plaster? What are the virtues of *ghooting*, *kutnee*, *Sylhet* and *shell* lime? Mention how these materials are obtained, and note the particular use each is put to, giving reasons.

4. How would you distinguish between cast-iron, wrought iron, and steel, judging from recent fractures? State briefly how these three kinds of iron are manufactured, for what purposes each is specially fitted and why, and state what local sources there are, if any, for obtaining them.

5. Distinguish between sâl, mahogany, bamboo, and teak (1) as living trees, (2) as timber: also compare them in regard to *size*, *durability*, *cost* and *utility*. In what ways is timber liable to decay in Bengal.

If a badly seasoned log of timber is sawn into planks show by means of sketches the alterations in form that are likely to occur.

6. What is the object of painting wood-work? What is the effect of paint upon unseasoned wood? What is meant by *priming* and describe what part white lead, linseed oil and litharge play in the process. State the relative advantages of paint and varnish in interior and exterior work.

7. What use is found for the following metals in engineering construction.

Brass, lead, zinc, copper, tin, nickel, gun-metal, platinum and galvanized iron.

State what you know of their composition, and deduce reasons for their being used in the way you mention.

8. What peculiarities are there in the manufacture and composition of the following—

Terra cotta, salt-glazed bricks, fire-clay, jhama bricks, earthen-ware pipes, window glass, and encaustic tiles.

Note any special qualities in the above, give instances of their use, and state how they may be obtained.

Chemistry.

Examiner—Mr. A. Pedler, F.C.S.

1. The following metals are gradually heated one by one to bright redness in a current of air; state exactly (*a*) what physical and (*b*) what chemical changes will take place in each case, expressing the chemical changes, if any, by equations:—

Copper, Gold, Silver, Iron, Magnesium, Zinc, Lead, Tin, Potassium Calcium and Aluminium.

2. Oxides of the following metals are heated to redness separately (*a*) with carbon and (*b*) in a stream of hydrogen gas; state exactly what will happen in each case:—

Aluminium, Copper, Zinc, Sodium, Iron, and Barium.

3. Explain clearly what is meant by the term Combustion. Describe the structure of an ordinary candle and coal gas flame, and state what is the usual source of luminosity in flames.

4. Describe clearly how Sulphuric Acid is manufactured. What is the action of dilute Sulphuric Acid on Gold, Copper, Zinc, Lead, Iron, Flint, and Carbon?

5. Define clearly the meaning of the following terms:—Atomic weight, isomorphism, acid, base, salt, acid salt, basic salt, and quantivalence.

6. What is meant by the term Alloy? Are alloys chemical compounds or not? Mention some of the principal alloys and give their composition, showing how the properties of the alloys compare with the properties of their constituents.

7. Explain clearly how Sodium Carbonate is made by LeBlanc's process, and by the ammonia-soda process.

8. What are the ores of Copper, and how can the metal be extracted? Mention the principal salts of copper and their uses.

9. What is the composition of Calc spar and of Chalk? How can Quicklime be obtained from them, describing the process as used on a manufacturing scale? How much Quicklime can be obtained from 600 pounds of pure chalk and how much slaked lime from this quicklime (Ca. = 40).

Heat and Light.

Examiner—Mr. A. Pedler, F.C.S.

1. Describe Breguet's thermometer and explain clearly how it acts. Also describe the Mercurial Weight Thermometer.

2. Describe the various methods which have been proposed for taking the vapour densities of substances and illustrate your description by specific examples.

3. What is meant by the "specific heat of gases at constant pressure and at constant volume" and how do these differ from each other, and why? State what influence pressure has on the melting point of solids and boiling point of liquids and give examples.

4. If one pound of hydrogen in burning in oxygen produces heat sufficient to raise 34,462 lbs. of water from 0° C to 1° C., calculate the theoretical temperature of a hydrogen flame burning (*a*) in pure oxygen, and (*b*) in atmospheric air, if the initial temperature is 0° C. Sp. Heat steam = ·4805, Sp. Heat nitrogen = ·2438.

5. Describe very briefly the parts of a locomotive engine. Trace the source of the power of such an engine from the fuel with which

the engine is fed. What is roughly the proportion of energy utilized in such engines, and why is it less than in certain other classes of engines?

6. Describe very briefly the various methods which have been used for measuring the velocity of the propagation of light.

7. Describe the construction of an astronomical refracting telescope and also of an ordinary terrestrial telescope, pointing out the exact object and use of each of their parts. How can the magnifying power of a telescope be determined.

8. Describe briefly the construction of a single prism spectroscope, and explain the various adjustments which would have to be performed before the instrument could be used with the best results. Explain the meaning of the terms Continuous spectrum, Absorptive spectrum, and Discontinuous spectrum. Describe the Solar spectrum.

9. Explain clearly what is meant by the interference of light. How would you show it experimentally and how can it be explained? What will be the appearance of a thin soap bubble (*a*) in ordinary day light, and (*b*) in yellow (sodium) light, and why?

Magnetism, Electricity and Telegraphy.

Examiner—Mr. A. Pedler, F.C.S.

1. Describe Coulomb's Torsion Balance, and shew how you would employ this instrument to verify the law of electrical repulsion and attraction.

2. Explain clearly which is meant by Electrical Induction. Describe several experiments to illustrate your meaning, and amongst them take up the cases of the production of electricity from an Electrophorus.

3. Describe a Holtz's Electrical Machine, and explain how it is worked. From what source is the energy of the electricity derived?

4. What are the laws of Electrolysis? Describe what happens when an electric current is passed through solutions of Zinc Sulphate, Sodium Sulphate, diluted Sulphuric Acid and Sodium Chloride? How are the changes which occur explained?

5. Describe and explain any two of the four processes of electro-typing, electro-plating, electro-gilding and nickel-plating.

6. It is stated that the Earth acts as a Magnet. Explain what is meant by this, and give reasons in support of the statement. What are the more important properties of the earth as a magnet?

7. What is meant by a Solenoid, and explain its construction? State what will happen when one end of a Solenoid, through which an eletric current is passing and which is suspended freely, is approached alternately by the two ends of a bar magnet? Explain these actions.

8. What is Ampére's theory of Magnetism, and show how this theory explains an ordinary method of Magnetisation?

9. Briefly describe and explain any two of the following apparatus:—

a. Wheatstone's Bridge. *b.* Ruhmkorff's Coil.
c. Gramme Machine. *d.* Telephone.
e. Microphone *f.* Any Arc Electric Lamp.
g. Any Incandescant Electric Lamp.

10 Describe and explain the Morse system of Telegraphy.

Drawing.

Examiner—Major A. D. McArthur.

[The figures should not be inked in, and all construction lines left. Marks will be awarded for neatness in drawing.]

1. What do you understand by the terms:—
Rhomboid, Trapezium, Prism, Tetrahedron, Orthographic Projection, Development, Helix, Traces of Planes.

2. A straight wire 2 inches in length is bent at its centre into a right angle, draw its projections on the horizontal and vertical planes when one arm is inclined 30° to the horizontal plane and the other is in any plane not parallel to the vertical plane.

3. Draw the projections of a cube standing on one of its angles, one face being inclined 30° to the horizontal plane.

4. Project on the horizontal and vertical planes the figure of a square prism of 2 inches sides and 4 inches length intersected by a right cylinder of 1 inch diameter, the axes of prism and cylinder intersecting at right angles.

5. What do you understand by the term Isometrical Projection. Draw the Isometric Scale.

6. Draw the isometrical projection of a box without a lid shewing its interior, the invisible lines to be dotted.

7. What is Perspective. Define the terms, Point of sight, Picture Plane, Vanishing Point, Horizon Line.

8. Draw to scale and in perspective a flight of 3 masonry steps with backing in right lines, the steps being inclined to the picture plane. The size of the steps and position and distance from picture plane and object may be assumed but these several dimensions should be figured on plan.

ENGINEER DEPARTMENT.

L. E. AND B. E. EXAMINATIONS.

Differential and Integral Calculus.

Examiner—Mr. C. Little, m.a.

1. Define the differential coefficient of a function of one variable. Deduce from the definition the differential coefficients of

$\tan x$, $a^{\sin x}$, $\log \cos x$, $\sqrt{a^2+x^2}$.

Differentiate (1) $b \tan^{-1}\left(\frac{x}{a} \tan \frac{x}{a}\right)$, (2) $x \sqrt{\frac{x^2-4a^2}{x^2-a^2}}$.

(3) $\log \sqrt{\frac{1+x\sqrt{2}+x^2}{1-x\sqrt{2}+x^2}}$, (4) $\frac{e^{a \tan^{-1} x}(ax-1)}{(1+x^2)^{\frac{1}{2}}}$.

2. If $y = x^3 \log x$ find $\frac{d^4y}{dx^4}$; also find the n^{th} differential coefficient of $e^{ax} \cos bx$ in the form $(a^2+b^2)^{\frac{n}{2}} e^{ax} \cos(bx+n\phi)$ where $\tan \phi = \frac{b}{a}$.

If $y = e^{rx} \sin x$, prove that

$$\frac{d^n y}{dx^n} - 2r\frac{d^{n-1} y}{dx^{n-1}} + (r^2+1)\frac{d^{n-2} y}{dx^{n-2}} = 0.$$

3. Enunciate Taylor's Theorem.

Prove that $\log \frac{\sin x}{x} = -\frac{x^2}{6} - \frac{x^4}{180} \ldots\ldots$

4. Define a maximum and a minimum value of a function of one variable.

Deduce criteria for the discrimination of maximum and minimum values. Show by means of a diagram how y may have a maximum value when $\frac{dy}{dx}$ is infinite.

5. Find the maximum and minimum values of the function $5x^6 + 12x^5 - 15x^4 - 40x^3 + 15x^2 + 60x + 17$.

6. Perform the following integrations :—

$$\int \sqrt{a+2bx+cx^2}dx \quad \int \frac{\sqrt{a^2+x^2}}{x}dx, \quad \int \log x\, dx,$$

$$\int \frac{dx}{(x-a)(x-b)(x-c)} \int \frac{3x^2-2x+1}{(x^2+1)(x^2+2x-1)}dx, \int \frac{d\theta}{1-\sin^4\theta}.$$

7. Show that $\int^a \phi(x)\,dx = \int_0^a \phi(a-x)\,dx$, and that if

$$\phi(x) = -\phi(2a-x), \quad \int_0^{2a} \phi(x)dx = 0$$

Evaluate $\int_0^{\pi} (16\cos^5\theta - 20\cos^3\theta + 3\cos^2\theta + 5\cos\theta)\,d\theta.$

8. Show how an expression of the form $\frac{(x^2-1)dx}{x\sqrt{a+2bx+cx^2+2bx^3+ax^4}}$ can be simplified for intergration by taking $x+\frac{1}{x} = z$, and use the method to integrate $\frac{(x^2-1)dx}{x\sqrt{1+x^4}}$.

9. Find the area bounded by two curves whose equations are $y = f(x)$ and $y = \phi(x)$ and two straight lines parallel to the axis of y.

Find the area included between a parabola and a circle on its latus rectum as diameter.

10. Find the length of any arc of the catenary

$$y = \frac{a}{2}\left(e^{\frac{x}{a}} + e^{-\frac{x}{a}}\right)$$

Hydrostatics.

Examiner—Mr. C. Little, M.A.

1. Deduce the principle of equal transmission of pressure from the fundamental property of a liquid, and explain how it may be indicated by experiment.

2. How is the measure of the density of a body found?

Prove that $W \propto g\rho V$, and explain the convention as to units by which the relation takes the form $W = g\rho V$.

If 3 cwt. be the unit of weight and 4 ft. the unit of length, find the density of the standard compared with that of water, the unit of time being one second.

3. Prove that the surface of a liquid at rest is a horizontal plane; also show that the pressures at two points in a liquid are equal, the points being so situated that the line joining them does not lie wholly in the liquid.

4. What is meant by whole pressure?

Find an expression for the whole pressure on a given surface exposed to liquid pressure.

An equilateral triangle with its plane vertical has its corners at depths n_1. n_2. n_3 below the surface of a liquid. If a be the length of a side, find the whole pressure and resultant pressure on it.

5. A conical vessel with its base horizontal is filled partly with mercury and partly with water. Internally the radius of the base is 6 inches, and height 18 inches. The volume of the mercury is seven times that of the water. Find the pressure on the base and on the curved surface having given that a cubic inch of water weights 250 grains and a cubic inch of mercury 3,400 grains.

6. Find the conditions of equilibrium of a body floating freely in a liquid.

A piece of cork whose weight is 19 ounces is attached to a bar of silver weighing 63 ounces, and the two together just float in water. The specific gravity of silver is 10·5 times that of water. Find the specific gravity of the cork.

7. A hollow cylinder open at the top is inverted and partly immersed in water; show that the height of the surface of the water within the cylinder is a root of the equation $x^2 + (a + h)x = (b - a)h$, when b is the length of the cylinder, a the length not immersed, and h the height of the water barometer. Which root must be rejected, and why?

Describe Smeaton's air pump, and find the density of air in the receiver after n strokes.

The capacity of the receiver of a Smeaton's air pump is $\frac{3}{4}$ that of the barrel, show that the upper valve will open during the third upward stroke when the piston has made $\frac{16}{37}$ of its ascent.

9. Describe Nicholson's hydrometer and explain how, by means of it, the specific gravities of a liquid and solid may be compared.

10. Define the centre of pressure, and find its depth for a vertical triangle wholly immersed in a liquid and with one side in the surface.

A vertical cylinder is filled with liquid: find the centre of pressure of the portion of its curved surface contained between two vertical planes through the axis.

Geology.

Examiner—Mr. A. Pedler, F.C.S.

1. Describe the macroscopic characters of the following rocks:—

Dolomite, Quartz, Micaceous Schist, Syenite, Laterite and Lignite. What are their essential constituents and general chemical composition?

2. Explain the general methods of formation of Sedimentary, Metamorphic and Granitic Rocks What are the characters of each? Explain the theories of Metamorphism.

3. Give definitions of the meanings of the following terms as applied in Geology, and where possible draw diagrams explaining your meaning:—Strike, Dip, Outcrop, Fault, Joints, Anticline and Syncline.

4. Give a detailed description of the geological functions or actions of water and ice; discussing the question (*a*) from a chemical point of view as producing chemical effects, & (*b*) from its purely mechanical effects.

5. Explain the theory of artesian wells.

6. Give a description of theories put forward to account for the formation of mountain chains.

7. Give the ordinary phenomena of volcanic action, and give any theories which have been put forward to account for them. What is the general distribution of volcanoes? Describe any volcanic effects present or ancient which exist within Indian limits.

8. Give a general outline of one of the following:—

(*a*) The Geology of the Himalayan area of India;
or (*b*) The distribution of coal in India.

Mineralogy & Metallurgy.

Examiner—Mr. A. Pedler, F.C.S.

1. Explain what is meant by the optical properties of minerals, and show how they are determined. What relations have been observed between the optical characters of minerals and their crystalline form?

2. Show the relation in the hexagonal form of crystallography between the rhombohedron, the hexagonal pyramid, and the scalenohedron.

3. State the more prominent facts relating to isomorphism in minerals. What are the principal isomorphous groups of elements occurring in minerals?

4. Describe the crystalline form and general characters, and give the chemical formulæ of the following minerals:—Diamond, Galena, Argentite, Gypsum, Hæmatite, Arragonite, and Tourmaline.

5. Give the principal minerals in which copper occurs, giving their names, chemical formulæ, crystalline form, general characters and usual percentage of copper.

6. Explain clearly the processes used in Idria and Almaden for the preparation of mercury, pointing out the advantages and disadvantages of each process.

7. Describe Plattner's process for the extraction of gold, and explain how the native gold is subsequently purified.

8. Explain the production of steel, (*a*) by the Cementation process; (*b*) by Bessemer's process; (*c*) by the Siemens Martin process. Within what limits may the composition of steel vary

9. Examine the composition of the different kinds of fuel used in metallurgical work, and state for what purposes each is most suitable. State why one kind of coal differs from another in heat giving power, and if possible give a method for obtaining the calorific intensity of fuel.

Details of Construction.

Examiner—Mr. W. Banks Gwyther.

Neatness and accuracy of sketches will be taken into consideration in awarding marks.

I.—What is the object of spreading out the foundations of walls? State what considerations would guide you in the design of footings; and when would you employ concrete as a stratum to build upon?

Criticize the foundations shown in sketches Nos. 1, 2, and 3, as applicable to Calcutta soil; and design foundations for the building illustrated in sketch No. 4, to be constructed on soil of a similar nature.

II.—Explain what is meant by 'bond'; discuss the principles in regard to it, and show to what extent they can be followed in the case of a square pillar of 1½ brick dimension. Sketch a flat arch in brick-work over a 4-feet opening, showing joints clearly and noting dimensions.

Explain how you would construct a wall with stone facing having a backing of brick-work.

III.—What do you understand by a damp-proof course? What materials are employed for it, and state the advantages and disadvantages of each?

What steps would you take in the construction of the room illustrated in sketch No. 5 to ensure its dryness?

IV.—Describe and illustrate a best quality panel door with frame, naming the several parts, and explaining clearly by means of sketches how the joints are made and the pieces secured together.

What fittings would you specify for such a door?

V.—What considerations determine the dimensions of 'tread,' 'rise,' and length of step in a staircase? What do you understand by the term 'landing'? What varieties are there, and under what circumstances are they used? Criticize a staircase consisting of an unbroken flight of 30 steps with 11″ tread, & 7½″ rise.

Describe the construction of a 'spandril' or 'featheredged' stone staircase, and explain the method of support.

VI.—A large area enclosed by walls is to be covered in to form a work-shed: the roof is to be of corrugated iron, carried on wrought iron trusses supported on parallel rows of T-iron posts, 16 feet apart.

Sketch clearly the arrangement of truss you would adopt making due provision for light and air, and for the removal of rain water. Give detailed sketches of the principal joints.

VII.—Explain and illustrate the following terms:—Lewis, dowel, flashing, trap, binder, jamb, rebate, tongue, and groove, dado, buttress, corbel, wiped joint, earth connection.

VIII.—It is proposed to build a small town hospital on the site indicated in sketch No. 6, the figures on which show the level of the ground at various points. The accommodation to be provided consists of—

Hospital containing 12 beds, with necessary adjuncts and a bathroom wing;
Out-patients' department;
Kitchen and store-rooms;
Laundry;
Dead-house and Post-mortem room;
Medical Officer's quarters;
Nurses' do.
Servants' do.
Latrine;
Gate-keeper's lodge;
Well—for drinking water.

Sketch roughly in outline, on the site plan, the positions and approximate sizes of the several buildings, stating briefly the reasons which guide you.

What superficial and cubic space would you allow for each bed in the hospital ward.

Roads and Railways.

Examiner—Mr. W. Banks Gwyther.

Neatness and correctness of sketches will be taken into account in allotting marks.

I.—What various considerations would guide you in the alignment of a metalled road between two places—say 100 miles apart?

If you were asked to get up a project for such a road, describe briefly what data you would obtain, what particulars you would furnish in your report, and what drawings you would prepare in illustration of your scheme.

II.—Sketch a cross-section of a 1st-class road in 4 feet embankment. Give a specification for a road of this class.

What materials are used for metalling in Bengal? What advantages does steam-rolling possess over the ordinary methods of road-rolling and when should it be resorted to.

Explain by means of sketches the use of *kerb* and *channel* stones.

III.—Show by a cross-section and rough plan of a hill cart road, how it would be drained: exemplify in these sketches the use of *breast-walls* and describe how *galleries* and *zig-zags* are formed.

What maximum gradients would you allow for a mule path and a cart road?

IV.—Describe and illustrate the construction of bridge foundations (*i*) on wells, (*ii*) by means of floating caissons, (*iii*) with concrete blocks, and (*iv*) by the aid of cofferdams.

What are the peculiarities in a *Bull's dredger*, *pulsometer*, and *sand pump?*

What development in the science of excavating has come into prominence in the construction of the Manchester Ship Canal?

V.—Under what circumstances would you use the following types of bridges (*a*) for the purposes of a road, (*b*) for a railway?

(*i*) Timber pile bridge.
(*ii*) Iron suspension bridge.
(*iii*) Masonry bridge.
(*iv*) Iron girder bridge.

Distinguish between a Warren and a Fink girder, and note the difference in constructive principles between the Forth and Jubilee bridges.

VI.—What do you understand by the *permanent way* for a railroad? Illustrate the system in use on the East Indian Railway. Also sketch clearly a section of the Calcutta Tramway Company's Lines.

VII.—How does the question of railway brakes stand at the present time.

VIII.—Describe what is known as the '*block system*' in connection with the traffic on a railway line.

What accommodation would you provide in a passenger building at a station such as Ranchi, supposing a Railway were constructed to pass through it.

HYDRAULICS.

Examiner—MR. G. C. STAWELL.

1. Find the equation for discharge from a rectangular orifice

2. A weir 100 feet wide is so placed that the depth of water is 4 feet above the crest in the up-stream side and 18 inches above the crest in the down-stream side. Calculate the discharge.

3. Find the relation of pressure and velocity in a forced vortex in which all the particles have the same angular velocity. Use the result to find the number of rotations of a centrifugal pump having 2 feet outside and 1 foot inside diameter, which is lifting water to a height of 49 feet.

4. Investigate a formula for dissipation of head in shock.

A thin edge sluice closes half the area of a pipe 2 square ft. in section. Find loss of head at the sluice when 10 c. ft. of water are discharged per second. Coefficient of contraction at sluice 0·6.

5. Obtain a formula for time of emptying a vertical sided lock chamber.

How does this compare with the equation for flow under a constant head?

A tank 16′ × 12′ contains 4½ feet depth of water. Find size of pipe to empty it in 10 minutes.

6. What are the laws of fluid friction?

A pipe is 1 ft. diameter and 500 ft. long, water flows through it at 10 ft per sec., and head lost in friction is 15 feet. Find resistance to flow of the water per square foot of the surface of the pipe and coefficient of friction.

7. What is meant by the Hydraulic gradient of a pipe?

A pipe 6 ins. in diameter is laid for a quarter of a mile at a slope of 1 in 50; for another quarter of a mile at a slope of 1 in 100, and for a third quarter is level. The level of the water is 20 feet above inlet end and 9 feet above the outlet end. Find the discharge (neglecting all losses excepting skin friction) and draw the hydraulic gradient. Mark the pressure in the pipe at each quarter mile.

8. Find an equation for the velocity of a uniform stream at any depth.

Where is the maximun velocity of a stream in calm weather?

9. Prove that in a channel with given side slopes and for a given discharge the section is least when the Hydraulic mean depth is half the actual depth. How in a simple way would you construct a channel to fulfil these conditions?

Applied Mechanics.

Examiner—Mr. W. B. Bestic.

1. Define the terms stress, strain, co-efficient of elasticity. Give examples of different kinds of co-efficients of elasticity, and of their numerical values in materials used in construction.

2. State the conditions necessary for stability of a plane bed joint in masonry. Explain what is meant by "line of resistance" of a blockwork structure, and show how it is obtained.

3. Prove that the greatest deviation of the centre of pressure from the centre of area of a horizontal bed joint in a solid cylindrical pillar of masonry, which is consistent with the condition that the pressure on the joint shall be nowhere negative, is one-eighth of the diameter. I for a circle $= \frac{1}{4} \pi R^4$.

4. State the conditions of stability for a masonry arch, and explain how you would proceed to ascertain whether or not an arch of any particular design would be stable.

5. Show how to find the pressure of a bank of earth on the back of a retaining wall in the case when the wall is vertical and the earth slopes at its angle of repose.

Assuming the thickness of the wall to be uniform, and treating it as constructed of a series of equal blocks, sketch the line of resistance.

6. Demonstrate completely that in the case of a beam supported at each extremity, the maximum bending moment due to a load concentrated at the middle of the span is double that due to an equal load uniformly distributed.

7. It is required to carry a floor of 24 feet span on rolled iron beams placed 8 feet apart. Assuming the greatest load on the floor (including its own weight) to be 200 lbs. per square foot, ascertain what would be a suitable section for the beams.

8. Describe the method of sections for ascertaining the forces in the bars of a frame, and state the three equations of equilibrium.

9. A Warren girder of 4 bays is supported by and loaded uniformly on the upper boom: prepare a table showing the relative forces in all the rods.

10. Define the following terms as used with reference to riveted joints:—lap and butt joints, single and double riveting, pitch, lap, gross and net section, single and double shear.

State 4 ways in which riveted joints are liable to fail, and derive a formula for the resistance to failure in each case.

Mechanism and Steam-engine.

Examiner—Mr. W. B. Bestic.

1. Explain what is meant by the pitch of spur-wheels.

It is required to drive a shaft at 40 revolutions a minute by a shaft which runs at 800 revolutions a minute, two pairs of spur-wheels and an intermediate shaft being used. Determine the number of teeth in a suitable set of wheels in which the large wheels are to be as small as possible, and the small wheels are to have not less than 16 teeth.

2. Sketch in outline the mechanism of Watts' parallel motion in one extreme position and superpose, in dotted lines, a sketch of the same mechanism in mid-position. Explain how the mechanism guides two points in approximately straight lines.

3. The driving wheels of a locomotive are 7 feet diameter and the stroke 22 inches. Find the speed of piston when the train is running 30 miles an hour.

Find also the horse-power of the locomotive, being further given that the mean effective pressure is 50 lbs. per square inch and the diameter of each cylinder 20 inches.

4. Show that the angular velocities of two cranks connected by a rigid link are inversely proportional to the perpendiculars from the axes of rotation on the line of connection.

5. An engine works with steam of 60lbs. pressure, cuts off at $\frac{1}{6}$ stroke, and has a back pressure of 3lbs. Find the mean effective pressure, and sketch an indicator diagram marking the pressure at the beginning, end, and 5 intermediate points of the stroke.

6. A fly-wheel 20 feet diameter revolves at 30 feet circumferential speed per second. Find the intensity of stress on transverse sections of the rim, supposing that the arms do not effect it.

7. Find the height of a simple revolving pendulum governor when the number of revolutions is given. Explain the construction of an ordinary governor.

8. Give a sketch showing the construction of a friction dynamometer. Describe how it is used, and state how the calculation of the horse-power exerted is made.

9. Calculate the net horse-power required to pump out a tank with vertical sides in 10 hours, the area of water surface being 10,000 square yards, and depth of water 10 feet; the water to be delivered at a height of 6 feet above the original water level.

10. Describe the observations, measurements, and calculation required to be made to determine the indicated horse-power of an engine. If a piston sweeps through 8 cubic feet per I.H.P. what is the mean effective pressure of the steam on it?

Drawing.

Examiner—Major A. D. McArthur.

Five only of these questions are to be attempted for which full marks can be gained. No lines should be inked. All construction lines should be clearly shown and lettered where necessary. Marks will be awarded for neatness in drawing.

1. A right prism with octagonal ends has one of its faces inclined 30° to the horizontal plane, and the horizontal projection of its axis makes an angle of 25° with the vertical plane. Draw its orthographic projections, the prism being 3 inches in length and side of regular octagon $\frac{3}{4}$ inch.

2. A plane inclined 45° to the vertical plane cuts the prism in the position drawn from the instructions in Question 1. Show the section on the horizontal and vertical planes.

3. By the addition of a right pyramid, one inch in height to one end of the prism in Question 1, the base of which coincides with the end of the prism, a rough representation of a tower is obtained. Draw the tower in isometrical projection.

4. A plane is represented by its traces, the horizontal trace making an angle of 45° with the vertical plane and the vertical trace an angle

of 60° with the horizontal plane. Assuming the projections of a point above the plane draw any line through the point inclined 45° to the given plane and show the point of contract with the plane.

5. A sphere of 1 inch radius rests on the horizontal plane. Assuming the horizontals of a plane, not perpendicular to the vertical plane, draw a plane parallel to the assumed plane, touching the sphere and indicate the point of contract.

6. Make a perspective drawing of the tower in Question 3, scale 1 foot=1 inch, under the following conditions :—

Distance of point of sight from front of tower=8 feet.
Distance of eye from picture plane—7 feet.
Distance of tower from picture plane=1 foot.
Height of eye=3½ feet.
Centre of tower to left of eye=2 feet.

Optional Paper.

MATERIALS OF CONSTRUCTION.

Examiner—MR. W. BANKS GWYTHER.

Forty marks to each question.

1. Note what you know of Portland cement manufacture under the following heads:— 'Raw materials and treatment,' 'burning,' 'grinding,' 'testing,' 'storage.'

2. Note what you know of its usefulness as a constructive material in regard to 'setting,' 'tensile strength,' and 'resistance to crushing' used neat, and used with varying proportions of sand. Give any examples of its use in Concrete, under water, in moving water, and in sea works.

3. What are the various methods employed in seasoning timber? Give a short description of each.

4. Note what cast-irons are most suitable for foundry purposes and give the distinctions between grey and white cast-iron, in composition, appearance and character. Note any reasons for and against the remelting of cast-iron to improve its quality.

5. Note differences between cast-iron, wrought-iron, and steel, and their relative strength and behaviour, when exposed to impact, compression, and tension. Give figures, and note what you know of Kirkaldy's experiments.

Optional Paper.

GEODESY.

Examiner—MR. G. C. STAWELL.

1. (*a.*) Describe the operations of a chain survey and note the points to be carefully observed.

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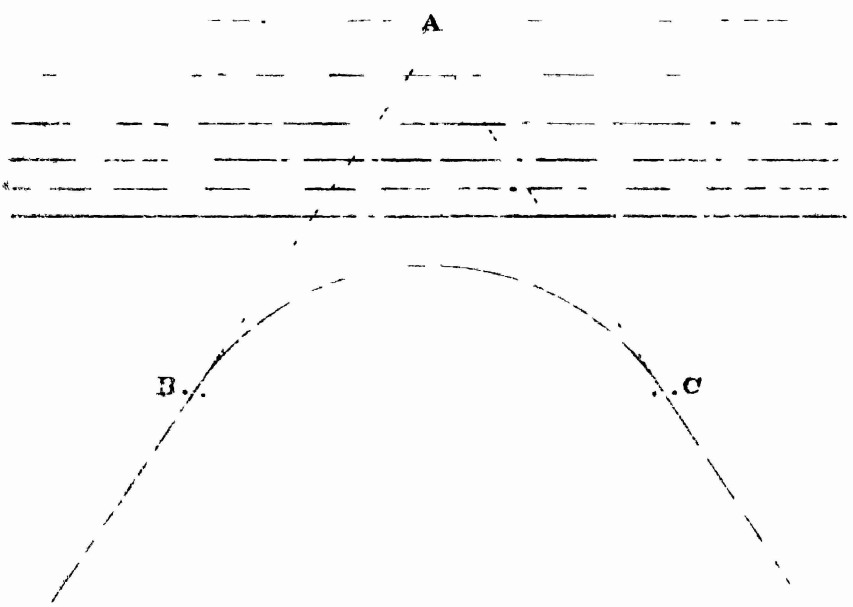
GEODESY.



(*b.*) A line, known to be 827·5 feet long, when measured with a Gunter's chain was found to be exactly 1250 links. Was this chain too long or too short, and by how much?

2. A gap occurs in a base line such as a large building which it is impossible to see over or chain across. Show how you would overcome this difficulty without the use of angular instruments.

3. From my position in a plain, a tower on the opposite bank of a river subtended an angle of 30° as measured with a box sextant, but on advancing 100 yards towards the tower, that is to the nearest bank of the river, the subtended angle was 60°. Required the breadth of the river and the height of the tower.

4. Draw up a form of level book with entries for at least six stations, and show how the entries should be checked.

5. What are—Flying levels.
Bench marks.
Parallax.
Line of collimation.
Contour lines.

6. What are the corrections for curvature and refraction? Up to what distance may they be neglected? How may they be neutralized.

7. Describe the temporary adjustments of the theodolite.

8. (*a.*) Explain the principal of the vernier.

(*b.*) On an arc divided into $\frac{1}{2}$ degree, the length of an attached vernier exactly covers a space of 13°, and is divided into 40 equal parts. To what degree of minuteness could you read this vernier?

9. Explain the method of taking two rounds of horizontal and vertical angles at a trigonometrical station.

In observing the second vertical reading the telescope is inverted, what error is thereby removed, and what by reading both verniers of the vertical arc.

10. How would you set out the curve BC? The intersection at A is inaccessible being in deep water.

Optional Paper.

ELEMENTS OF HEAT, LIGHT AND ELECTRICITY.

Examiner—MR. A. PEDLER, F.C.S.

1. What do you understand by the theory of undulation in connection with the cause of heat? Use the theory to explain the phenomena of heat in solids, liquids and gases: and describe how heat is transmitted in these three forms of matter.

2. Describe the construction and use of Daniell's hygrometer, and the wet bulb hygrometer, and point out in what respects these instruments differ from the chemical hygrometer.

3. What amount of Hydrogen by weight would be necessary to heat 68·924 kilos. of water from 0°C to 1°C ?

4. Define latent heat, specific heat, calorific intensity and carlorific power.

5. Into 1000 grams of water at 0°C, 100 grams of steam are passed at a temperature of 100°C. What will be the temperature of the water ?

6. Describe the optical principles on which the construction of the camera lucida, and camera obscura depend; and mention any use to which these instruments are applied.

7. State what you understand by the thermal analysis of solar light.

8. Describe how magnetization may be produced by currents, explain the construction of an electro-magnet, and point out in what particulars it differs from an ordinary magnet. Refer briefly to some of the uses of electro-magnets.

9. What do you understand by a *constant current:* and enfeeblement of a current ? Describe the construction of two of the commonest forms of cells in use which afford constant currents: and indicate the points to which special attention must be paid in the construction of such batteries.

10. Explain the use of the torsion balance to prove the laws of electrical attractions and repulsions.

11. State generally the influence of pressure and temperature on the solubility of gases and solids in water.

Optional Paper.

CHEMISTRY.

Examiner—MR. A. PEDLER, F.C.S.

1. A certain compound was found to possess the following percentage composition:

Mg	...	21·65
P	...	27·92
O	...	50·43
		100·00

Calculate its formula.

2. Mention the most important natural lime compounds, and give their constitutional and graphic formulæ. Describe the most delicate tests for lime in the wet way, and state the reactions by which you would distinguish between sulphate of lime and sulphate of barium.

3. Explain fully what occurs when chlorine gas is passed into (1) a hot concentrated, (2) a cold dilute solution of KHO. What occurs

when the dilute solution is subsequently boiled? Give equations to represent chemical changes.

4. Describe the preparation of metallic alluminum. Give a short account of its chemical and physical properties, and refer to any technical uses to which the metal is now applied.

5. Into what classes can *oxides* be divided? Give general methods for the preparation of oxides, and illustrate your reply by examples.

6. Describe the preparation and chemical properties of sulphur trioxide, and explain why sulphur acts as a hexad in it, and as a tetrad in the dioxide.

7. Describe the method of preparation and chemical composition of the following pigments:—

1. Indian or Venetian red.
2. Vermilion.
3. Chrome red.
4. Chrome yellow.
5. Brunswick green.
6. Mineral or Scheele's green.
7. Prussian blue.
8. Umber.

8. By the electrolysis of a certain weight of water 12946·2 c.c. Hydrogen and 6473·1 c.c. Oxygen were obtained, both gases being measured at 12°C and under a pressure of 762 mm. What was the weight of water used in the experiment?

9. Describe the preparation and properties of nitrogen dioxide, and state how you could convert it into the trioxide.

10. Explain the action of nitric acid—if any—on the following substances, and give equations—Zinc: Arsenic trioxide; Tin; Gold; Ferric chloride; Sulphuretted Hydrogen; and Ferrous sulphate.

Optional Paper.

MIXED MATHEMATICS.

Examiner—MR. C. LITTLE, M.A.

1. From a point O within a quadrilateral lines OA, OB, OC, OD are drawn to the corners. Find where O must be in order that forces represented in direction and magnitude by these four lines may be in equilibrium.

2. A uniform rod, 4 inches in length, is placed with one end inside a smooth hemispherical bowl of which the axis is vertical and the radius $\sqrt{3}$ inches long. Show that one-fourth of the rod will project over the rim of the bowl.

3. Three equal heavy rods AB, BC, CD are rigidly connected together so as to form three sides of a square, and the system is suspended from the point A; prove that if θ be the inclination of AB to the vertical, $\tan\theta = \frac{3}{4}$.

4. Two equal heavy particles on two equally rough inclined planes of the same height, and placed back to back, are connected by a string passing over the top of the planes. Show that when the particles are on the point of moving the limiting angle of resistance will be half the difference of the inclination of the planes.

5. There are four pulleys in which the strings are vertical, and all attached to the weight. What weight can be supported by a force of 14 lbs. and what force can support a weight of 14 lbs. (1) if the weights of the pulleys themselves can be neglected, and (2) if each pulley weighs 1lb.?

6. Three velocities whose ratios are $\sqrt{3} + 1 : \sqrt{6} : 2$, are simultaneously impressed on a particle and the particle does not move; find the angles at which the directions of the velocities are inclined to each other.

7. If a, b, c be the spaces described by a body moving with uniform acceleration in the p^{th}, q^{th} and r^{th} seconds, shew that

$$a(q - r) + b(r - p) + c(p - q) = 0.$$

8. If t be the time in which a projectile reaches a point P and t' the time from P till it strikes the horizontal plane through the point of projection, prove that the height of P above that plane is $\frac{1}{2}gtt'$. Hence verify the expression for the greatest height.

Optional Paper.

PURE MATHEMATICS.

Examiner—MR. C. LITTLE, M.A.

If α, β be the roots of the equation $x^2 + px + q = 0$, prove that the equation the roots of which are $\frac{\alpha}{\beta^2}$ and $\frac{\beta}{\alpha^2}$ is $q^2x^2 + (p^3 - 3pq)x + q = 0$.

2. Sum the following series—

(1) $1 + 3 + 7 + 13 + 21$ ..... to n terms.

(2) $(2n - \frac{1}{2}) + (4n + \frac{1}{6}) + (6n - \frac{1}{18})$ ..... to n terms.

3. Find approximately the number of minutes denoting the inclination to the horizon of an incline which rises $5\frac{1}{2}$ feet in 420 yards.

4. (1) If $\sin \alpha = \tan \beta$, prove that

$$\sin(\alpha - \beta)\cos\beta = \sin 2\beta \sin^2 \frac{\alpha}{2}.$$

(2) Eliminate θ between the equations

$$x = a\cos\theta + b\cos 2\theta$$
$$y = a\sin\theta + b\sin 2\theta.$$

5. Prove that the area of the triangle contained by two tangents from the point (x_1, y_1) to the circle $x^2 + y^2 = r^2$ and their chord of contact is $\frac{r(x_1^2 + y_1^2 - r^2)^{\frac{3}{2}}}{x_1^2 + y_1^2}$.

6. If the normal to a parabola $y^2 = 4ax$ at P meet the curve again in Q, and if y_1, y_2 be the ordinates of P and of the middle point of PQ respectively; shew that $y_1\, y_2 = -4a^2$.

7. In the hyperbola $x^2 - y^2 = a^2$, if the chord of contact have the same length as the axis, the pole will lie on the curve whose equation is $2x^2\,(x^2 - y^2) = a^2\,(x^2 + y^2)$.

8. If an acute-angled triangle ABC perpendiculars AD, BE are let fall on BC, CA respectively; circles described on AC, BC as diameters meet BE, AD respectively in F, G and H, K; shew that F, G, H, K lie on the circumference of a circle.

9. If P be a point on a parabola, PG the normal cutting the axis in G, and Q the middle point of SG, prove that $QX^2 - QP^2 = 4AS^2$, where X is the foot of the directrix.

ENGINEER DEPARTMENT.

List of Bachelors and Licentiates in Engineering of the Calcutta University.

	Year.	Present or last appointment.
B. C. E.		
Bhut Nath Chattopadhyay ...	1879	Assistant Engineer, East Coast Railway, Madras.
Upendro Nath Chattopadhyay ...	1879	Pleader, Monghyr Bar.
Bama Charan Sen	1880	Overseer, 1st grade, Public Works Department, Chittagong.
Surendro Kumar Bose ...	1880	Teacher, Civil Engineering College, Sibpur
Upendro Nath Bandyopadhayay ...	1880	District Engineer, Birbhum.
Annadaprosad Sircar	1883	Assistant Engineer, 1st grade, Orissa.
Hari Pada Ghosal	1883	Builder and Contractor, Calcutta.
Rajendranath Mukhopadhyay ...	1883	Overseer, 1st grade, 2nd Calcutta Division.
B. E.		
Sorabji Shavaksha	1886	Assistant Engineer, 1st grade, Public Works Department, Buxar.
Beni Madhab Mittra	1887	Assistant Engineer, 2nd grade, Public Works Department, Sone Circle.
Nogendra Nath Mukhopadhyay ...	1888	Assistant Engineer, 3rd grade, Public Works Department, Orissa.
Satish Chandra Chattopadhyay ...	1889	Overseer, 2nd grade, Public Works Department, Singhbhum.
Adhor Lal Chandra	1889	Calcutta Municipal Corporation.
J. B. Godfrey	1890	Temporary Assistant Engineer.
Po Thoung	1890	Unknown.
Khirode Chandra Mukerjee ...	1890	2nd grade overseer.
Haridas Ganguli	1890	Ditto.
Giris Chandra Das	1891	Practical training.
Mohini Mohan Lahiri ...	1891	Ditto.
L. C. E.		
Atul Chandra Bandyopadhyay ...	1880	Overseer, 1st grade, Public Works Department, Chota Nagpur, Bengal.
Nogendro Nath Bandyopadhyay ...	1880	Overseer, 1st grade, Public Works Department, Assam.
Bhabadeb Chattopadhyay ...	1880	Contractor, Madras.
Ashutosh Chattopadhyay ...	1880	District Engineer, Singhbhum.
Gopal Chandra Chattopadhyay ...	1880	Overseer, 1st grade, Public Works Department, Chota Nagpur.
Abhoya Charan Dutt ...	1880	Calcutta Municipal Corporation.
Jnanendro Nath De	1880	Out of employment.
Bama Charun Mukhopadhyay ...	1880	
Abinash Chander Roy ...	1880	Supervisor, Public Works Department, Assam.
Radha Raman Guha	1880	Officiating Teacher, Civil Engineering College, Sibpur.
Satya Charan Bandyopadhyay ...	1881	Overseer, 1st grade, Public Works Department, Dacca.

L. C. E.—*continued.*	Year.	Present or last appointment.
Lalit Mohan Basack ...	1881	Out of employment.
T. B. Byers	1881	Ganjam Railway.
P. W. Byers	1881	Supervisor, District Board, Gaya.
Pran Krishna Sen	1881	Overseer, 1st grade, Public Works Department, Orissa.
Bhushan Chandra Bandyopadhyay	1882	Overseer, 1st grade, Public Works Department, Gondock.
Sita Prasanna Roy	1882	Overseer, 1st grade, Public Works Department (Examiner, lightning conductors, Bengal).
Hari Prosad Ghosal	1883	Overseer, 1st grade, Public Works Department, Dacca.
J. A. Martin	1883	Public Works Department, India Government.
C. P. Warde	1883	Assistant Engineer, 1st grade, Public Works Department.
Akhil Chandra Marik... ...	1885	Overseer, 2nd grade, Mahanuddy Division.
Banku Behari Mukhopadhyay ...	1885	Overseer, 1st grade, Public Works Department, Chota Nagpur.
L. E.		
W. A. E. Hanby	1885	Assistant Engineer, Public Works Department, Bengal Railways.
Hpo Thine	1886	Assistant Engineer, Public Works Department, Burma.
H. E. W. Martindell	1888	Assistant Engineer, Public Works Department, Burma.
Hari Charan Mukhopadhyay ...	1888	Out of employment.
Surendro Nath Barat ...	1888	Overseer, 2nd grade, Sone Circle.
V. B. Webber	1888	Temporary Assistant Engineer, Burmah.
Nabakumar Chakrabarti ...	1889	Temporary Teacher, Civil Engineering College.
Gyanendro Nath Gangopadhyay...	1889	Temporarily employed, Santipur Municipality.
Krisnadhone Bandyopadhyay ...	1889	Overseer, 2nd grade, Orissa.
Kalibar Bhattacharyya ...	1889	Deceased.
Rajendro Nath Mukhopadhyay ...	1889	2nd grade Overseer, Krisna Nagore.
W. S. Bremner	1889	Assistant Engineer, 3rd grade.
Sarat Chander Sen	1889	Assistant Surveyor, Surveyor-General's office.
Trailokya Nath Mazumdar ...	1890	Unknown.
Nagendra Nath Mitra ...	1890	Temporary Assistant Engineer, Burmah, Public Works Department.
F. F. Bion*	1890	Assistant Engineer, Burmah.
Mahendra Nath Dutt ...	1890	Assistant Engineer, Public Works Department Bengal.
Jadu Nath Das	1890	Unknown.
Bankim Krishna Ghose ...	1890	Temporary Overseer, Public Works Department.
Abdul Rahman	1890	Unknown.
G. J. St. C. Sedgley	1891	Practical training.
Satyaranjan Khastgir ...	1891	Ditto.
Upendra Nath Mukhopadhyay ...	1891	Ditto.

N. B.—Any inaccuracies in the above list should be brought to the notice o the Principal. Passed students out of employ should register their names and addresses in the Principal's office. It is particularly requested that on any student getting an appointment or changing his appointment, the information be forwarded to the Principal for incorporation in the College Calendar.

ENGINEER DEPARTMENT.

SCHOLARS AND MEDALLISTS.

Forbes' Memorial Scholars.

1880 { Bhusan Chandra Bandyopadhyay.
Kali Gopal Rudra.

1881 Not awarded.

1882 { C. P. Warde.
Hari Pada Ghosal.

1883 W. A. E. Hanby.

1884 { Tarak Chandra Ghose.
Hpo Thine.

1885 Not awarded.

1886 { H. E. W. Martindell.
Hari Charan Mukhopadhyay.

1887 { Nogendra Nath Mukhopadhyay.
Rajendra Nath Mukhopadhyay.

1888 { Adhor Lal Chandra.
W. S. Bremner.

1889 { Mohindra Nath Datta.
Haridas Gangopadhyay.

1890 { Giris Chandra Das.
Modhu Sudan Sen Gupta.

1891 { Ahindra Chandra Mukhopadhyay.
Amullya Kristo Bhattacharjee.

Ambika Charan Chaudhuri Medallists.

1880 Upendro Nath Bandopadhyay.

1881
1882 } Not awarded.

1883 Rajendra Nath Mukhopadhyay.

1884 } Not awarded.
1885 }

1886 Sorabji Shavaksha.

1887 Beni Madhab Mittra.

1888 Nogendro Nath Mukhopadhyay.

1889 Satish Chandra Chattopadhyay.

1890 Khirode Chandra Mukhopadhyay.

1891 Giris Chandra Das.

Trevor Medallist.

1891 Mohini Mohan Lahiri.

CIVIL ENGINEERING COLLEGE, SIBPUR.

APPRENTICE DEPARTMENT.

GENERAL RULES.

1. The College is under the general supervision of a Board of Visitors appointed by the Government.

2. The Principal of the College is charged with the general control of the Institution, including the regulation of the course of study, the supervision of the mess and other domestic arrangements, and the maintenance of discipline; and he will from time to time issue such rules as may be necessary to secure those objects. The workshops are under the control of the Executive Engineer, and the apprentices while at work in them will be under his orders; but all breaches of discipline will be reported by him to the Principal.

Rules for Admission.

3. For admission to the Apprentice Department a candidate must be between the ages of 15 and 17.

4. An examination for admission will be held annually at the College on the second Monday in January. Every candidate must apply in writing to the Principal, not later than the 31st December, for permission to appear at the examination, enclosing a fee of Rs. 2, a certificate of good conduct and a certificate of age. Applications unaccompanied by fee and certificates will not be considered. The subjects of examination are—

Arithmetic (the whole).	Euclid (Books I and II).
Algebra to simple equations, inclusive.	English (grammar and composition).

Candidates who have passed by Standard VII of the Code for European schools, or the University Entrance examination in English and Mathematics are admitted without further test.

5. Every applicant, before admission to the College, will be examined by the College Surgeon as to his physical strength, chest measurement, fitness for manual labour, and eyesight. If this officer's report is unsatisfactory, the applicant will not be admitted: his fee, however, will be returned.

6. Before an apprentice is admitted to the College, his parent or guardian must sign an agreement in the form shown in Appendix A.

7. The session begins on the first Monday in February. All apprentices are required to join the College on that date. Any

apprentice prevented by sickness from attending on the opening day must produce a certificate to that effect from a Civil or Assistant Surgeon, failing which he will be liable to a fine not exceeding Rs. 10. No apprentice will be admitted or re-admitted to the College after the close of the month of February, except by special order of the Director of Public Instruction. This permission will only be given under exceptional circumstances. Those students, however, who passed the last Entrance examination will be eligible for admission to the Department up to the first Monday in April.

Course of Instruction.

8. There will be a long vacation from about the middle of August to the end of October. Every apprentice must leave the College during this vacation, and parents or guardians must satisfy the Principal, before their sons or wards can be admitted, that they are able to conform to this rule.

9. The full course of instruction in this class will extend over five years, during the first three and-a-half of which the instruction will be both theoretical and practical. The last year and-a-half will be spent entirely in practical work. For details of the course of study, *see* Appendix B.

10. Every apprentice who passes the annual examination held at the end of the second year will be entitled, on leaving the College, to a certificate, stating that the holder possesses the theoretical qualifications required of a sub-overseer in the Public Works Department.

11. An apprentice who passes the final examination held at the end of three years and-a-half will be entitled to a third grade overseer's certificate.

12. On the completion of his practical course, an apprentice will be entitled to a first or second grade overseer's certificate according to the estimate formed of his work by the College authorities. A College certificate gives the holder no claim to a Government appointment.

13. No apprentice who at the end of three years and-a-half leaves the College with a third grade overseer's certificate will at any future time be allowed to return for his practical course.

14. Every apprentice who leaves the College after the expiration of the five years' course will receive a certificate in the form shown in Appendix C, provided that he has attended the workshops on 80 per cent. of working days during the last 18 months of his apprenticeship.

[Note :—
Extract from the "Calcutta Gazette" *of the 16th March* 1887, *page* 79, *Part I.B.*

A candidate for employment on the Subordinate Engineering Staff of the District Engineer must be qualified in one of the manners following, that is to say :—
(1) If the pay of the appointment is Rs. 60 per mensem, or more, he must hold—
(*a*) a certificate from the Principal of the Government Engineering College at Sibpur that he has served his apprenticeship there and passed the final examination qualifying him for employment in the Public Works Department as a Foreman Mechanic or an Upper Subordinate.]

15. Apprentices will attend in the class-rooms and in the workshops in accordance with the College time-table. The hours of work may vary with the seasons of the year.

16. All apprentices will be required to reside on the College premises, so far as the accommodation will permit.

FREE AND REDUCED FEE LIST.

17.* European or Eurasian apprentices, up to the number of twenty-five, are received into this Department on payment of Rs. 5 a month for the twelve months of the year. The cost of messing is estimated at Rs. 20 a month. In the case of these twenty-five apprentices, the balance, viz. Rs. 15 a month, will be paid to the mess fund by Government. In addition five such apprentices are admitted free. Thus the total of free apprentices and apprentices on a reduced fee will be thirty.

18. Europeans and Eurasians in excess of that number will be received as apprentices into the College, so far as the accommodation will permit, on paying the full cost of their messing, viz. Rs. 20 a month. This charge will be payable during the term, reckoned at nine months and-a-half. During the vacation, taken at two months and-a-half, a charge of Rs. 2 a month will be made to defray the cost of maintaining mess servants.

19.* Native apprentices up to the number of forty will be received into the apprentice department on payment of Rs. 2 a month for the twelve months of the year. The cost of messing is estimated at Rs. 7 a month. In the case of these forty apprentices, the balance, viz. Rs. 5 a month, will be paid to the mess fund by Government.

20. Native apprentices in excess of this number will be received into the College on paying the full cost of their mess, viz. Rs. 7 a month. This charge will be payable during the term, reckoned at nine months and-a-half. During the vacation, reckoned at two months and-a-half, a charge of Re. 1 a month will be made to defray the cost of superintendence and mess servants.

STIPENDS.

21. After the final examination, 10 stipends of Rs. 10, and 10 of Rs. 6 each, tenable for one year and-a-half, will be awarded to those apprentices who pass the best examination, both theoretical and practical.

STANDING ORDERS FOR STUDENTS.

22. Every resident European apprentice will join the European mess. On joining the mess every apprentice will pay an entrance fee of Rs. 10 to the mess fund to provide for the cost of crockery, knives and forks, table linen, &c. A list of breakages and other damage done will be prepared monthly, and each apprentice will be required to pay, by the 15th of the following month, an equal share of the cost. On leaving the mess, if an apprentice has paid all demands, his

* These rules apply only to apprentices whose parents or guardians reside within the limits of the jurisdiction of the Lieutenant-Governor of Bengal; but the sons of East Indian Railway employés, of soldiers serving in India, and of Survey, Telegraph, and other Government officers who are liable to be employed in Bengal, are admissible to the reduced fee list.

entrance fee will be returned to him ; otherwise it will be forfeited to the mess fund.

23. Hindu apprentices must ordinarily join the College mess for Hindus, and abide by the rules sanctioned by the Principal for the management of their mess. Each student on joining the mess will be required to deposit " caution money " to the amount of Rs. 5, which will be ultimately returned to the student if he has not rendered himself liable to the forfeiture of the whole or any part of it.

24. Each resident apprentice must provide his own clothing and bedding and a bedstead. No furniture may be brought into the College without special permission.

25. All payments must be made into the Principal's office on or before the 15th of the month for which the money is due, after which date no payment will be taken unless accompanied by a fine of Re. 1 for every three days of delay. If the payment is not made during the month for which it is due, the defaulting apprentice's name will be struck off the College books and he will not be re-admitted until he has paid all arrears with fines.

26. The monthly charge for messing may, if necessary, be altered from time to time in reference to the prices of provisions.

27. All breaches of discipline committed by any apprentice will be reported to the Principal, who will dispose of them according to the rules and practice of the Education Department.

28. A conduct register of each apprentice will be kept by the Principal. The Principal has no power to cancel or alter an entry once made and signed.

29. Apprentices are liable to have their names placed in the conduct register as defaulters for the following offences :—

(I)—Disobedience of orders.
(II)—Absence without leave.
(III)—Idleness.
(IV)—Insubordination or disrespect to the College or workshop authorities.

30. Apprentices may be removed from the College for habitual or gross misconduct, for continued idleness, or neglect of work, or for frequent entry in the conduct register. Every such removal should be reported to the Director of Public Instruction, and any fees paid by the apprentice shall be forfeited.

31. Every apprentice will be responsible for any machines, tools, or other articles that may be placed in his charge. He must produce them when called upon to do so, and must at once report any damage done to them. In case of loss or damage arising from carelessness, he may be called upon to pay the cost.

32. A certain number of the apprentices will be appointed monitors, whose duty it will be to assist the College authorities in the maintenance of discipline. For the performance of this duty each monitor will receive a small sum monthly.

33. Any monitor may be removed by the Principal for misconduct or for inefficiency in the discharge of his duties.

34. No resident apprentice will ordinarily be allowed to keep a private servant.

35. On Sundays all resident Christian apprentices, Protestant and Roman Catholic, will be required to attend the services held in their respective chapels.

36. All apprentices will be required, while in the workshops, to wear a uniform dress, which will be supplied to them at cost price.

37. Leave will be granted by the Principal only. No leave will be granted except on a written application.

38. No resident apprentice may leave the College premises without the written orders of the Principal, whether on special leave or on a general holiday.

39. All European apprentices will be encouraged to join the Volunteer Corps. Those who join it will be allowed such occasional leave as may be required by the regulations relating to Volunteers.

40. All apprentices are obliged to join the College Athletic Club, the subscription to which is Re. 1-8 per annum, and the entrance fee one rupee.

APPENDIX A.

CIVIL ENGINEERING COLLEGE, SIBPUR.

Memorandum of the conditions under which _____ *is admitted as a Mechanical Apprentice to the Civil Engineering College, Sibpur.*

1. He will be subject to the regulations set forth in the "Rules of the Mechanical Apprentice Class."
2. He will pay his own travelling expenses to Sibpur.
3. He will be on probation for six months: at the end of which time, if it appears that he is not physically fit for the work, or if for any reason (other than misconduct) it appears inexpedient to retain him, he will be sent back to his friends at the expense of Government.

4. The undersigned _____

will for five years, beginning from the date of admission to the College,

provide _____

with suitable clothes and the books required in his class; and will pay in advance to the Principal of the College, on or before the 15th of each month, the sums stated in Rules 17, 18, 19, 20, 22, 23 and 24. He will also make arrange-

ments for the removal of _____

from the College during the long vacation, under Rule 8, or any other time when required by the Principal.

5. In consideration of the foregoing conditions, _____

_____

will be fed and lodged for a period of five years (excluding vacations), and will receive such instructions as will qualify him for employment as an Upper Subordinate in the Public Works Department and as a Foreman Mechanic.

6. Employment is not guaranteed after completion of apprenticeship.

Signature of parent or guardian { _____

Address.

Signature of witness. { _____

Address.

Signature of the Principal, Civil Engineering College, Sibpur.

_____

Dated the *day of* 189

APPENDIX B.

Course of Study for the Apprentice Department.

	First year, Feb. to Aug.	Second year, Nov. to Aug.	Third year, Nov. to Aug.	Fourth year, Nov. to Aug.
Mathematics ...	Arithmetic, the whole. Euclid Books III, IV, VI, and definitions of V. Todhunter's Algebra to end of Chapter 32, omitting scales of notation. Mensuration.	Algebra to end of Binomial Theorem. Trigonometry. Mensuration.	Statics, Besant's Hydrostatics, Chapters I to IV, inclusive.	Todhunter's Mechanics for Beginners, articles 1 to 50, Chapters VII, VIII, IX, XVII, and article 152. Hydrostatics, Chapters V to VII, inclusive.
Engineering ...	Carpentry	Estimating; Building materials.	Masonry; Estimating, Roads.	Applied Mechanics, Mechanism and the steam-engine, Buildings, Bridges.
Natural Science	.....	Chemistry	Heat	Electricity and Magnetism.
Surveying ...	.....	Surveying with chain and prismatic compass, and Levelling.	Plane Table, Box-sextant, Theodolite and Levelling.	Laying out curves, and Fieldwork generally.
Drawing ...	Printing Scales, Geometrical drawing.	Orthographic projection ...	Engineering and Machine drawing.	Sketching and Machine drawing.

APPENDIX C.

Leaving Report of , *an Apprentice*
in the Engineering College, Sibpur.

Entered	18	Age on entering	years	months.
Apprenticeship expired	18	Age on leaving	,,	,,
Left	18			

Apprentice appeared at the final examination held on the , and obtained marks as follows :—

Subject.	Full marks.	Marks obtained.	Remarks.
Mathematics			
Natural Science			
Surveying			
Drawing			
Engineering			
Ditto (practical course)			
Total ...			

Apprentice has spent time in the shops as follows :—

	Time spent in each.	Proficiency
Carpenters' shop	Months.	
Blacksmiths' ,, ...	,,	
Moulders' ,, ...	,,	
Fitters' ,, ...	,,	
Founders' ,, ...	,,	

Apprentice held the post of Monitor for months.

Apprentice's character is as follows as regards the qualities mentioned :—

I.—Truthfulness.
II.—Industry.
III.—Energy.
IV.—Obedience.

General Remarks.

Conclusion.—On the whole we consider that this apprentice is qualified for employment in the Public Works Department as a

Executive Engineer,
Calcutta Workshops Divn.

Principal, Civil Engineering College,
Sibpur.

Sibpur,

The 18

APPRENTICE DEPARTMENT.

WORKSHOP COURSE.

Workshop Hours, Junior Apprentices 8—11. Senior Apprentices 8—11 and 12-30—4.

First year.

Carpenters' shop.—Apprentices are made acquainted with and shown how to use and handle properly the tools ordinarily employed for the purposes of carpenters' and joiners' work. They are taught the methods of preparing wood, setting out, and forming the various joints. The practical application of the foregoing instruction is brought to bear by employing them in making tools, boxes, doors, windows, roof trusses and other framings required for buildings and other engineering works.

Second year.

Blacksmiths' and Boiler-makers' shop.—Apprentices are taught to use and handle correctly the different tools, to lay and manage the fires, to draw down, bend, jump, weld, split, punch, chamfer and temper. After this they are set to make small forgings of tools, bolts, nuts, hooks and shackles, and also of parts of trusses, as well as other forgings of parts of machines. In the boiler-makers' shop they are familiarised with the use of riveting tools and the process of riveting, and learn to punch and shear correctly with the machines for that purpose.

Third year.

Vicemen and Fitters' shop.—The apprentices are put through a course of chipping, filing, and fitting so as to gain experience in the tools used by this class of workmen, after which they make up various tools required in the fitters' shop and assist in ordinary fitting work. Those who prove themselves sufficiently proficient are then put on as attendants to the workmen employed on the different machines so as to acquire a knowledge of lathe-work, such as facing, surfacing, turning, boring, and screw cutting, and also shaping, drilling, slotting and planing in the machines used for these purposes. They thus gain confidence in using these machines so as to be entrusted to work them by themselves.

EXAMINATIONS.

Annual examinations are held at the end of the first, second and third years. Each apprentice has to produce within a given time certain tasks allotted him bearing upon the instruction received during the course of the year. These examinations are held personally by the Executive Engineer.

Fourth year.

Foundry or moulding shop.—Only six months of the apprentices' time is devoted to this shop. They learn to use the various moulders' tools, to mix foundry sand and loam, to make small moulds from patterns supplied, and are shown how to ensure good work and clean castings. They are also taught how to prepare and charge the cupolas. An insight into the nature of the wooden patterns required for forming the moulds being thus obtained, they are set to work with the pattern-makers to make small patterns from which they are expected to produce castings.

EXAMINATIONS.

At the end of the three and-a-half years the apprentices having gone through the various shops have a final examination, and in a given time have to produce pieces of work requiring the use of the different tools used in the respective shops to show that the skill acquired by them has been maintained, and that they show sufficient mechanical aptitude to be considered fit to complete their apprenticeship. During the three and-a-half years' theoretical instruction in the College and practical training in the workshops are simultaneously carried on, but during the remaining one and-a-half years they are solely employed in the shops, and are designated "senior apprentices."

Fourth and Fifth years.

Senior Apprentices.—Are employed independently on the lathes, drills, shaping, slotting, planing, punching, shearing and screwing machines, and are taught to set out and mark off work for them, these machines being brought into use to make tools, machines, parts of engine and pump fittings, and any other instructive work that may be going on in the shops. They assist generally in the repairs to the hulls and machinery of dredgers and launches, also in repairs to portable engines, centrifugal, donkey and other pumps. They are taught to make steam joints, pack glands, set valves, and get up steam and drive engines so as to be competent to take charge of (as well as carry out any necessary repairs to) portable or fixed engines and boilers or a steam-launch. They are also instructed in laying out work to full size on the drawing boards, from drawings, for the use of the workmen.

APPRENTICE DEPARTMENT.

ADMISSION EXAMINATION, 1891.

ARITHMETIC AND ALGEBRA.

1. Simplify $\dfrac{2 + \frac{3}{4} + \frac{1}{3} + \frac{1}{12} - \frac{1}{2}}{\frac{2}{5} \times 4\frac{1}{6} + \frac{1}{2}} \div \dfrac{\frac{1}{3} + \frac{1}{6}}{1 - \frac{1}{3} \times \frac{1}{4}}$.

2. Find the value of ·375 of 21*s.* + $\cdot\dot{5}\dot{4}$ of 8*s.* 3*d.* + $\cdot 0\dot{2}\dot{7}$ of £2 15*s.*

3. Extract the square roots of $4\frac{5}{8}$ and of $\dfrac{\cdot 0011}{330}$ to 4 places of decimals.

4. The floor of a room is 19 feet 7 inches long and 18 feet 9 inches wide. How many yards of carpet 25 inches wide will cover the floor, and what will it cost at Rs. 2-4 per yard?

5. A tradesman bought a quantity of goods and sold $\frac{3}{4}$ of them at a profit of 5 per cent.; the price rising he got 12 per cent. on the remainder, and on the whole gained £108: what sum did he lay out?

6. If Rs. 520 amount to Rs. 624 in 4 years, what sum will amount to Rs. 662-8 as. in 5 years at the same rate?

7. Divide $x^5 - y^5$ by $x - y$, and subtract $(a + b)\, x^2 - (a^2 - b^2)\, (y^2 + z^2)$ from $(a - b)\, x^2 - (ay + bz)\, (ay - bz)$.

8. Resolve $6x^2 + 7x + 2$, $x^6 - 8y^6$, $a^2 - 2ab + b^2 - c^2$, $x^4 + x^2y^2 + y^4$ into elementary rational factors.

9. Extract the square root of $\left(x + \dfrac{1}{x}\right)^2 - 4\left(x - \dfrac{1}{x}\right)$.

10. Solve the equations:—

(*a*) $\dfrac{x}{2} - \dfrac{3x - 4}{5} = x + \dfrac{2x + 3}{4} - 2\frac{3}{4}$.

(*b*) $x - 2 + \sqrt{x^2 + 4} = 3$.

(*c*) $\dfrac{30}{y - x} + \dfrac{44}{y + x} = 10, \dfrac{40}{y - x} + \dfrac{55}{y + x} = 13$.

11. If $\dfrac{a}{b} = \dfrac{c}{d}$, show that $\dfrac{a + b}{a - b} = \dfrac{c + d}{c - d}$, $\dfrac{a^2 + c^2}{a^2 - c^2} = \dfrac{ab + cd}{ab - cd}$.

12. A train travelling 27 miles an hour takes 14 minutes longer to go down from Calcutta to Burdwan than one which travels 30 miles an hour; what is the distance to Burdwan?

GEOMETRY.

1. (*a*) Explain the following geometrical terms:—Converse theorems, problems, a corollary, the letters QEF and QED.

(*b*) Define:—A trapezium, an oblong, a rectangle, an altitude, and a gnomon.

2. Write down the three postulates and the eighth and ninth axioms.

3. (*a*) Any two sides of a triangle are together greater than the third side

(*b*) BC, the base of an isosceles triangle ABC, is produced to any point D, show that AD is greater than either of the equal sides.

4. Triangles on the same base and between the same parallels are equal in area.

5. (*a*) To describe a square on a given straight line.

(*b*) Write down the corollary of this proposition.

6. The square described on the diagonal of a given square is double of the given square.

7. To divide a given straight line into two parts, so that the rectangle contained by the whole and one of the parts may be equal to the square on the other part.

8. (*a*) If a straight line be divided into any two parts, the squares on the whole line and on one of the parts are equal to twice the rectangle contained by the whole and that part, together with the square on the other part.

(*b*) Prove this also algebraically.

N.B.—Abbreviations may be employed in answering the questions.

ENGLISH.

1. Dictation.

2. What do you mean by simple, compound and complex sentences? Give an example of each, and express your example of a complex sentence in simple sentences.

3. Give the plurals of potato, German, loaf, child, story, address, index, cross.

4. Form adjectives from the following words:—

Brass, college, slave, sleep, man, master, pleasure, religion, security, fortune.

5. What is meant by tense, mood and voice of verbs. Define transitive, intransitive and auxiliary verbs. Illustrate your answer by examples.

6. Form short sentences introducing the following expressions:—Lookout, break up, let go, no good, after all, at least, as soon as, bear out.

7. Correct the following sentences:—

(1) This is one of the most important cases which has recently been decided.
(2) I have much pleasure to give it to you.
(3) The room was filled with so much people as it could hold.
(4) If I fall, I will break my leg.

8. Turn into indirect narration—

"We are a body of men who are trained to judge public questions. We have laboured together in the cause of our country, and it would cause me deep grief if anything were said to-day to render it impossible for us to labour together in the cause. It is needless for any man to call to my mind the services of Mr. ———. I am well aware of them. I have good cause to know them. I stood beside him in the original struggle for the formation of our party. I have humbly shared his labours, and I have done my best to make them effectual."

9. Write a short essay on the changes produced in Indian life by the steam-engine.

APPRENTICE DEPARTMENT.

MONTHLY EXAMINATION.

MARCH 1891.

4th year.

1. What is the object of jacketing cylinders? Give a rough sketch of a jacketed cylinder (longitudinal section). What is the object of leaving a small space at the end of each stroke between piston and cylinder covers, and what is this space called?

2. What do you understand by "the principle of virtual velocities" and modulus of a machine? If a pump engine of 10 H.P. raises 20 cubic feet of water to the mean height of 17½ feet per minute, what is the modulus of the pump?

3. Sketch a system of *pullies*, so that by two moveable pullies the ratio of P. : W. may be as 1 : 5.

4. A train of 100 tons ascends an incline which has a rise of 6″ in 100 feet. Find the maximum speed at which the train will run up the incline if the H.P. of the engine be such that the speed on the level portion of the rail may be as high as 30 miles per hour (the H.P. is effective H.P.). Find also the effective H.P.

5. Prove the formula $P = Wh^2 \tan^2 \frac{a}{2}$. a = horizontal thruts, W = weight per cubic foot of earth, h = ht. of wall, a = complement of the angle of repose.

6. Find an equation to compute the breadth of a retaining wall; P = horizontal thrust, W = weight per cubic foot of masonry.

7. What practical addition may be made to the calculated breadth for different kinds of material?

8. (*a*) What is Professor Rankine's principle in lieu of giving any practical increase to the breadth of the base of a retaining wall.

(*b*) What is the best practical form of retaining wall. What will it be in the case of a dam?

9. A certain substance becomes electrified when it is rubbed with a silk handkerchief. How would you determine whether its electrification is positive or negative?

10. Describe an ordinary plate machine, and explain how the prime conductor becomes charged with electricity.

11. A rectangle 10 feet long and 4 feet broad is placed with its plane vertical and one of its long edges on the surface of water. Find the resultant pressure on the rectangle.

12. A body has an initial velocity of 20 miles per hour; after 1 minute its velocity is found to be 50 miles per hour; assuming that a constant force acts upon the body, find the acceleration in foot-seconds; or, find the centre of pressure of a triangle with an angular point on the surface and its base horizontal.

Third year.

1. Distinguish and illustrate the difference between heat and temperature, or describe the general effects of heat upon solids, liquids, and gases.

2. How is the boiling point determined? What degree Fahr. corresponds to 35°C?

3. Define the co-efficient of linear expansion. The length of a brass wire is 150 yards at 0°C and 150·141 yards at 50°C. Find its co-efficient of linear expansion.

4. How is $K_2 CO_3$ manufactured from ashes?
What happens (*a*) when lime-water (*b*) when hydrochloric acid is added to a solution of $K_2 CO_3$?

5. (*a*) Prove $\tan^{-1}\frac{1}{2} + \tan^{-1}\frac{1}{3} = 45°$; (*b*) $A = \tan^{-1}\frac{1}{7}$, $B = \tan^{-1}\frac{1}{3}$. Shew that $A + 2B = 45°$.

6. Define the logarithm of a number to a given base. Prove $\log \frac{m}{n}$ to the base $a = \log_a m - \log_a n$. What are the logarithms of ·01, 1, 100, to the base ·01.

7. (*a*) Given L sin 14° 24′ = 9·3956581, L sin 14° 25′ = 9·3961499. Find the angle whose L sin is 9·3959449.

(*b*) Prove $\tan \frac{A-B}{2} = \frac{a-b}{a+b} \cot \frac{C}{2}$.

8. (*a*) Explain the principle of "transmissibility of force."
(*b*) Compare the densities of two substances, A and B, when the weight of 3 cubic inches of A = weight of 4 cubic inches of B.

9. Describe, with sketches, the mode of well-sinking with jham.

10. Sketch Fouracres's ordinary well excavator.

11. Describe, with sketches, a coffer dam.

12. Describe "Pierre perdue" foundation.

Second year.

1. Distinguish between an element and a compound. How would you show that red mercuric oxide is a compound?

2 Does any chemical change take place when red hot charcoal is introduced into a jar of oxygen gas?
Give reasons for your answer.

3. Describe and explain what takes place when burning phosphorus is introduced into a jar of oxygen gas.

4. How is oxygen prepared?
How much oxygen is contained in 100 lbs. of $KClo_3$.

5. Find the volume of a portion of an embankment on a perfectly level ground when the length of the portion is 800 feet, breadth of the top of embankment 20 feet, height of embankment 15 feet, and the ratio of side slopes $1\frac{1}{2}$ to 1.

6. Sketch any instrument for finding the accuracy of side slopes of earthworks, and explain the method of using it, and how the necessary slope is given to the whole bank.

7. Explain the terms:—catch-water drains, spoil bank, profile, length of lead.

8. Prove that an angle is expressed in the circular system by the fraction which has for its numerator the arc subtended by that angle at the centre of any circle, and for its denominator the radius of that circle An arc subtended by an angle at the centre of a circle is 1 5708 times the radius. Find, in degrees, the measure of the angle.

9. Find the numerical values of sec 15° and tan 15° if sin 15° $=\frac{\sqrt{3}-1}{2\sqrt{2}}$ and cos 15° $=\frac{\sqrt{3}+1}{2\sqrt{2}}$.

10. Express in grades the angles of a regular octagon and in circular system the angles of an isosceles right-angled triangle.

11. The carpeting of a room $1\frac{1}{2}$ times as long as it was broad at annas 4 per square foot cost Rs. 96, and the painting of the walls at Rs. 2 per 100 square feet cost Rs. 19·20. Find the dimensions of the room.

12. The sides of a triangle are 25, 39 and 56 feet respectively. Find the areas of the two triangles into which it is divided by the perpendicular from the angle opposite the longest side.

1st year.

1. If $2s = a + b + c$, show that

$$\frac{1}{s-a} + \frac{1}{s-b} + \frac{1}{s-c} - \frac{1}{s} = \frac{abc}{s(s-a)(s-b)(s-c)}$$

2. Solve the equations $\frac{x+a}{a} - \frac{2x}{x+a} = 3 - \frac{x^3 - ax^2}{a^3 - ax^2}$.

3. $\left.\begin{aligned} \frac{2}{x} + \frac{1}{7} &= \frac{3}{z} \\ \frac{3}{z} - \frac{2}{7} &= 2 \end{aligned}\right\}$; $\frac{1}{x} + \frac{1}{z} = \frac{4}{3}$.

4. A man takes $1\frac{1}{2}$ hours to row a distance of 11 miles down stream, but takes $2\frac{3}{4}$ hours to come back the same distance upstream. Find the velocity of the stream.

5. Prove Euclid II·4.

6. Prove do. II·7.

7. Prove do. I·6.

8. Prove do. I·15.

9. How are sedimentary rocks formed ?

10. Describe the blasting process.

11. Define dressing, and describe it.

12. Name the stones which are generally used for engineering works, naming the nature of works for which each is specially used.

APRIL.

4th year.

1. State the three different formulæ of Gordon for resistance to compression, and write the values of the constants used in them for cast iron, wrought iron, and timber.

2. A weight of 10 tons is to be suspended by a wrought iron rod; find its diameter: given $s = 5$, $f_t = 25$ tons per square inch of section.

3. Draw the stress diagram of a kingpost truss of 30 feet span, the inclination of the rafter to the horizontal being 30° and W the weight upon it. Draw to any scale of proportional parts.

4. Shew in the above truss how you will find the two reactions graphically when there is a wind pressure P on one side. Find also the tension of the tie beam.

5. A stone is projected vertically upwards with a velocity which will carry it to a height of 64 feet; find its velocity when the height is 16 feet, or prove that $s = vt - \frac{1}{2}ft^2$.

6. Determine the conditions of equilibrium of a floating body.
Define metacentre.

7. Enunciate Boyle's law, and describe any simple experiment by which it may be verified.
The pressure of a gas is 14 when the volume is 25 cubic feet; find its pressure when the volume is 150 cubic feet.

8. What is meant by electrolytic polarisation ? How is it prevented ? Explain the construction of a Daniell cell.

9. Give a sketch of a cross head commonly in use in a factory engine which runs in one direction. Given mean P = 50 lbs.; diameter of cylinder = 1 foot; ratio of crank to connecting rod = 1 : 6. Find the maximum pressure on slide bar.

10. Sketch a D slide valve, and explain the action of outside and inside lap on the valve.

11. Give a sketch of a compound screw; find the ratio of $\frac{W}{P}$ in it. Why are square-threaded screws stronger than V threaded screws, and on what do the power and strength of a screw depend?

12. The area of the piston of a high-pressure engine is 144 square inches; the length of the stroke = 3 feet; the pressure of steam in the cylinder = 48 lbs.; number of strokes per minute 20; and the loss by friction as usual. It is required to find the useful H.P. of the engine.

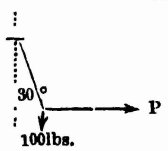
3rd year.

1. If *A B C* be the angles of a triangle, prove the following relation:—$\text{Cos}^2 A/2 + \cos^2 B/2 + \cos^2 C/2 = 2 + 2 \sin A/2 . \sin B/2 . \sin C/2$.

2. Enunciate and prove the "Triangle of forces."

3. (*a*) If three forces acting on a particle keep it in equilibrium, each force is proportional to the sine of the angle between the directions of the other two.

(*b*) A weight of 100 lbs. is suspended by means of a string, and a force P acts *horizontally* at the point where the weight is fastened, the inclination of the string to the vertical being 30°. Find P and the tension of the string.



4. *A B C* is a triangle, and O any point within it; like parallel forces act at *A B C*, which are proportional to the areas *BOC*, *COA*, and *AOB* respectively. Show that the resultant acts at O.

5. The algebraical sum of the moments of two like parallel forces round any point in the plane of the forces and between them is equal to the moment of their resultant.

6. Show how you will scarf a beam to resist transverse strain, giving reasons for your answer.

7. How are iron fastenings in timber protected against rust?

8. Briefly describe the different methods of lowering centres.

9. A pond is just about to freeze. Will the surface water or the water at the bottom be the warmer? Why? Water is said to have its maximum density at 4°C. Explain what this means.

10. Describe a gridiron pendulum. What must be the ratio between the lengths of the bars of the two metals, and why?

11. The volume of a certain quantity of air is 1200c.c. at 30°C and under a barometic pressure of 28 inches. Find the volume at 0°C and under a barometric pressure of 30 inches.

12. Describe the manufacture of soda from common salt.
How is soap prepared?

2nd year.

1. What reasons can you give in support of the statement that water is a compound of hydrogen and oxygen? or describe the experiment by which it was shown that 2 volumes of hydrogen combine with one volume of oxygen to produce water.

2. Describe the properties of hydrogen.

3. How is nitrogen prepared from air?

4. Hydrogen is passed over heated copper oxide. The loss of weight is $\frac{2}{3}$ gram. Find the amount of water produced.

5. Explain by sketches and short descriptions the different methods of making embankments. Which would you prefer for embankments of tanks above ground?

6. Explain the following terms:— (1) puddle-gutter, (2) bond, (3) Flemish bond, (4) batter, (5) Lewis, (6) closer, (7) block-in-course masonry.

7. Show by sketches how bricks are to be arranged in English bond in 2-brick thick walls at the corner.

8. Trace the changes in the size and magnitude of the cosine of an angle as it increases from 0° to 360°.

9. Prove the following:—

$$\text{Cot}^2 A - \cos^2 A = \text{cot}^2 A . \cos^2 A.$$

Find the values of cos A and cot A when $\sin A = \frac{1}{\sqrt{3}}$

10. A circular grass plot whose diameter is 40 yards contains a gravel walk one yard wide running round it one yard from the edge; find what it will cost to turf the grass plot at 4*d.* per square yard.

11. The sides of a rectangle are in the proportion of 4 to 5, and the area is 180 square feet. Find the sides.

12. When are numbers said to be in harmonical progression. If H = harmonical mean, G = geometrical mean, A = arithmetical mean, then show that $G^2 = AH$.

Or — Insert 11 harmonical means between 1 and $\frac{1}{13}$.

1st year.

1. Describe the process of burning bricks in a clamp. State the defects of the system.

2. Describe Bull's kiln.

3. Define the terms—"Tempering," "Slop and sand-moulding," "Slaked Lime," "Artificial Cement," and "Concrete."

4. Give Vicat's classification of limes.

5. Divide a straight line so that the rectangle contained by the whole and one of the parts may be equal to the square on the other part.

6. Construct a square equal to a given trapezium.

7. Bisect a parallelogram by a straight line drawn through a point given in one of its sides.

8. Extract the cube root of 245678914.

9. Find the value of—

$$£\ 2{\cdot}32\dot{1} + 1{\cdot}3\dot{5}\ gs. + \tfrac{2}{3} \text{ of } £\ 5.\ 18s.\ 4d. + 4{\cdot}\ddot{5}\dot{6}\ cr.$$

10. Extract the square root of $7\sqrt{3} - 12$.

11. Find a factor which will rationalise $\sqrt[3]{5} - \sqrt{2}$.

12. Solve the equations—

$$2\left(\frac{\frac{1}{x}-\frac{1}{a}}{x+a}\right) = 5.$$

$$\sqrt{2x} - 7x = -52.$$

MAY.

4th year.

1. A body weighing 4lbs. is projected up a rough inclined plane with a velocity of 16 foot-seconds, and just reaches the top of the plane. The inclination of the plane to the horizon is 60° and the coefficient of friction is tan 30. Find the length of the plane and the measure of the pressure upon the plane.

2. Describe Smeaton's air-pump, and shew how to find the density of the air in the receiver after n ascents of the piston.
Or explain how Nicholson's hydrometer is used to find the specific gravity of a solid heavier than water.

3. State Ohm's law.
If the resistance of 130 yards of a particular copper wire $\frac{1}{16}$ inch in diameter is an Ohm, express in that unit the resistence of 8,242 yards of copper wire $\frac{1}{12}$ inch in diameter.

4. Describe Ruhmkorff's coil.
Or the ends of two copper wires leading to a concealed Grove's battery are free. How would you find out, by means of a solution of copper sulphate, which wire is connected with the platinum and which with the zinc end of the battery.

5. Shew by a sketch the different stresses produced under a transverse load, (1) in a cantilever, (2) in a beam both ends freely supported.

6. Design the scantling of a *sâl* beam to support a flat roof weighing 120lbs. per square foot. Beams to be 4 feet apart from centre to centre and 15 feet span. $P_b = 800$.

7. Define "bending moment" and "shearing force." Find the bending moment and shearing force of a uniformly loaded beam at 5 feet from one end. The span is 20 feet and load is 2 tons per foot run.

8. Sketch graphically the diagrams of bending moment and shaering force of a cantilever when uniformly loaded.

9. Explain the action of forcing pump with air chamber. What is its defect? Sketch a pump which acts similarly but without the disadvantage.

10. Sketch the part of machine generally adopted in steam engines to change continuous circular into reciprocating rectilinear motion, and any machine to change reciprocating rectilinear into continuous circular motion.

11. Draw an indicator diagram of a low-pressure expansive engine, steam being cut off at one-third of the stroke, and explain the figure.

12. From the diagram how would you estimate the mean pressure of steam? What data in addition to the diagram would you require before you could calculate the power exerted by the engine, and what more do you learn from the figure?

3rd year.

1. What are the necessary conditions of equilibrium of a system of forces acting in one plane on a rigid body?

2. State and prove the condition of equilibrium of a constrained body.

(*b*) ABC is a triangle without weight, having a right angle at C, and CA is to CB as 4 is to 3; the triangle is fixed at C, and two forces P and Q acting at A and B in direction at right angles to CA and CB keep it at rest. Find the ratio of P to Q.

3. Define centre of parallel forces, and find the centre of like parallel forces of 7, 2, 8, 4, 6 lbs, which act in order at equal distances apart along a straight line.

4. Solve the triangle ABC when C is a right angle; given $a = 840$, $c = 841$, log $a = 2\ 9242793$, log $c = 2{\cdot}9247960$, log $41 = 1{\cdot}6127839$, log $1681 = 3\ 2255677$. L sin 87°—12′ = 9·9994812. L sin 87°—13′ = 9·9994874.

5. Calculate the quantity of masonry in the above drain bridge.

6. Define specific heat.

If 3lbs. of mercury at 90°C. be mixed with 2lbs. of water at 25°C., find the temperature of the mixture. Specific heat of mercury = ·033.

7. Explain the importance of knowing specific heat in experiments on conduction. How can it be shown that iron is a better conductor of heat than bismuth?

8. How can a recently plastered room be dried quickly? What is the composition of air-slaked lime? Give the percentage composition of calcium carbonate.

9. Mention the tests of calcium carbonate.

2nd year.

1. What are the advantages of hollow walls? How are they made? What do you understand by pise'-wall?

2. What are the principal things to be attended to in preparing the foundation of a masonry structure?

3. What is meant by *well-foundation?* Sketch Fouracres's simple well-excavator, and explain its action.

4. Solve the following equations:—
(*a*) $\tan\theta + \cot\theta = 2$. (*b*) $4\sec^2\theta - 7\tan^2\theta = 3$.

5. Prove the following relations:—

(*a*) $\sec(180 - A) = -\sec A$. (*b*) $\operatorname{cosec}\left(\frac{\pi}{2} + \theta\right) = \sec\theta$.

(*c*) $\frac{\operatorname{cosec}\theta}{\sec\theta} + \frac{\sec\theta}{\operatorname{cosec}\theta} = \sec\theta.\operatorname{cosec}\theta$.

6. Find the value of $\sin(-675°)$ and $\sec\frac{29\pi}{4}$.

7. Find how many superficial feet of *inch* plank can be sawn out of a log 20 feet 4 inches long, 1 foot 10 inches wide, and 1 foot 6 inches deep.

8. Find how many pieces of money $\frac{3}{4}$ of an inch in diameter and $\frac{1}{8}$ of an inch thick must be melted down in order to form a cube whose edge is 3 inches long. What sort of figure is a prismoid?

9. State and illustrate the law of multiple proportion, and show that it follows from the atomic theory. Give a list of monad elements.

10. Describe the tests of nitric acid.

11. Describe and explain what happens (*a*) when copper is added to nitric acid, (*b*) when a glowing chip of wood is introduced into a jar of laughing gas. Give reactions.

12. How much nitric acid can be prepared from 40lbs. of nitre?

1st year.

1. If α and β be the roots of the equation $px^2 + qx - r = 0$; form the equation whose roots are $\frac{1}{\alpha}$ and $\frac{1}{\beta}$.

2. Solve the equations—

$$\frac{x+y}{x-y} + \frac{x-y}{x+y} = \frac{5}{2}\,;\quad x^2 + y^2 = 45.$$

3. $$\frac{x}{y+z+1} = \frac{7}{x+z} = \frac{z}{x+y-1} = x + y + z.$$

4. Find three consecutive numbers whose product is equal to 15 times the middle number.

5. Find, by practice, the rent of 123 acres 3 roods 35 perches of land at the rate of £3. 18*s*. 11*d*. an acre.

6. If 15 men or 20 women can do a piece of work in 20 days, how long will 8 men and 12 women take to do it?

7. The opposite angles of a quadrilateral figure inscribed within a circle are together equal to two right angles.

8. Angles in the same segment of a circle are equal to one another.

9. *ABC* is a triangle, *D* is any point inside it; prove that the sum of *AD*, *BD* and *CD* is greater than half the sum of *AB*, *BC*, *CA*.

10. Define the terms—Bond, English bond, Flemish bond, ashlar masonry, coursed rubble masonry, through stones, pith, heart wood and sap wood.

11. What is seasoning timber? Describe water seasoning and natural seasoning.

12. Name the works for which the following timbers are used:—
Sal, teak, deodar, babool, bamboo, box, and sissu.

JUNE.

4th year.

1. Draw the section, with dimensions, of an outside main wall, of a two-storied house, constructed of bricks of size 10″ × 5″ × 3″; height of 1st story from ground = 20 feet; height of 2nd story = 16 feet; width of room = 15 feet; weight of a cubic foot of masonry = 120lbs. The ground on which the building will stand is capable of supporting 1 ton per square foot. Make the plinth 5 feet high and foundation 4 feet high.

2. How can floors be made damp proof? What means are generally adopted to prevent white ants from appearing above floors.

3. State the principal causes of the waste of fuel in boilers.

4. Make a sketch illustrating the ordinary weighted lever safety-valve. What are its defects?

5. A body weighing 3lbs. and moving with a velocity of 10 feet per second, impinges upon a body weighing 6lbs. and moving with a velocity of 5 feet per second; find the velocities after impact, $e = \frac{1}{3}$.

6. A weight of 2lbs. is drawn up a smooth plane inclined at an angle of 30° to the horizon by a weight of 2lbs. which descends vertically, the weights being connected by a string passing over a smooth pulley at the top of the plane; find the acceleration and the space described in 5 seconds from rest.

7. The volume of 1lb of steam at 221°F. = 22·34 cubic feet. The tension = 17·53lbs. per square inch. Find the internal work done in vaporising the water.

8. Define pressure at a point. Find the pressure at any given depth in a liquid at rest.
Find the force on a horizontal plane of 5 square feet placed 2 feet deep in glycerine (sp. gr. 1·25).

9. A cantilever beam of timber 14 inches deep, 10 inches thick, projects from a wall for a length of 10 feet; what is the greatest load that can be safely put on it, the load being uniformly distributed? Safe intensity of stress for timber is $\frac{3}{4}$ tons per square inch.

10. Prove the formulæ T or C $= \frac{W}{2DL}(Lx - x^2)$ for a beam, when W = whole uniform load; D = depth of girder; L = length of the girder; and x = distance from the nearest abutment or support.

11. When does the greatest shearing force occur at any section of a girder for a moving load? Give your reasons.

12. A plate girder 20 feet span carries a moving train $1\frac{1}{2}$ tons per foot run; find the greatest shearing force at section 5 feet from the support.

3rd year.

1. Define latent heat. How did Black determine the latent heat of water?

2. Steam at 100°C. is passed into 10lbs of ice-cold water until 71bs. of water at 57·8°C. are obtained. Find the latent heat of steam.

On sprinkling some water at 80°F. on the floor of a room the temperature of which was also 80°F. and the doors and windows of which had been kept shut for some time, the temperature of the room at once fell a few degrees. How do you explain this?

3. Describe the properties of metallic zinc and the tests of aluminium salts.

4. How is glass manufactured?

A substance is suspected to be $MgCO_3$ How would you proceed to determine whether your supposition was correct or not?

5. The primary scale is graduated to 10ths and half-tenths of an inch, and 24 divisions of the primary scale correspond to 25 divisions of the vernier; to what can you read by this vernier?

6. Explain the following:—Line of collimation, optical axis, focus, parallax and to repeat an angle.

7. State the condition when a traverse makes a complete circuit, and also the rules for finding the bearings of various sides, the bearing of one side and the interior angles being given.

8. The sides of a triangle are 2, $\sqrt{6}$ and $1 + \sqrt{3}$; find the angles.

9. When a body is placed on a horizontal plane, it will stand or fall according as the vertical line drawn through its centre of gravity falls within or without the base.

10. Why is a sphere always in equilibrium in any position on a horizontal plane? Show that if a portion be cut off by a plane, it will be in equilibrium with its sectional surface horizontal.

11. Define a lever. Divide levers into classes, with examples of each kind.

12. One force is four times as great as the other, and the forces are on the same side of the fulcrum, and the pressure is 9lbs on it; find the positions and magnitude of the forces.

2nd year.

1. Describe the properties of diamond, graphite and charcoal. How can it be shown that they are different forms of one and the same element?

2. What happens (*a*) on heating a mixture of copper oxide and charcoal; (*b*) on passing CO_2 over red-hot charcoal; (*c*) on heating coal in air? Give reactions.

3. What happens when coal is heated in a retort?

Mention the ingredients (*a*) of impure and (*b*) of purified coal-gas.

4. Describe the properties of chlorine and experiments you would perform in illustrating them.

5. Submit the estimate with abstract of cost of the room estimated in class during the last month.

6. Describe the different ways of laying foundations in water.

7. What sort of clay is suited for brick-making and what for tile-making? How will you make a sample of earth which contains 90 per cent. of clay suitable for brick-making.

8. Show that $\sin (A + B) = \sin A \cos B + \cos A \sin B$ when $A = 120°$ and $B = 45°$, and find the value of $\sin 165°$.

9. Prove that $\sec 2\theta - \tan 2\theta = \dfrac{1 - \tan \theta}{1 + \tan \theta}$ and

$$\text{Sin } A = \frac{2 \tan \frac{A}{2}}{1 + \tan^2 \frac{A}{2}}.$$

10. Find a value of θ to satisfy $\sin \theta - \cos \theta = \dfrac{\sqrt{3} - 1}{2}$.

Show that $\sin\left(\frac{\pi}{3} + a\right) - \sin\left(\frac{\pi}{3} - a\right) = \sin a$.

11. Find the volume of the pyramid formed by cutting off a corner of a cube whose side is 16 feet, by a plane which bisects its three conterminous edges.

12. The height of a frustum of a pyramid is 4 inches; the lower end is a rectangle which is 9 inches by 12; the upper end is a rectangle of which the longer side is 8 inches. Find the volume of the pyramid.

1st year.

Solve the equations—

1. $\dfrac{x}{y} + \dfrac{y}{x} = \frac{5}{2}$; $xy = 8$.

2. $\dfrac{x + 3}{x - 3} + \dfrac{y - 3}{y + 3} = 2$; $\dfrac{x - 3}{2x + 3} + \dfrac{y - 3}{2y + 3} = 1$.

3. If x be real, find the limits of the values of—

$$\frac{x^2 - 2x - 3}{2x^2 + 2x + 1}$$

4. The perimeter of a sector of 30° is 100 feet; find the radius.

5. Through the middle of a circular plot of ground of 20 feet radius runs a flower bed 5 feet broad; find the cost of fencing the bed at the rate of 2s. per foot.

6. If two lines intersect within a circle, the rectangle contained by the segments of one is equal to the rectangle contained by the segments of the other.

7. Straight lines bisecting the angles in the same segment of a circle pass through a fixed point.

8. A person changes his 4 per cent. stock at 93 and buys 5 per cent. stock at 105; find the change in his income.

9. In what time will £1,500 amount to £1,800 at $3\frac{1}{2}$ per cent. simple interest.

10. Define the terms— ore, alloy, soldering, open sand, moulding, and distemper.

11. How is wrought-iron made from cast-iron?

12. Describe the nature of works in which wrought-iron is used in preference to cast-iron.

State the advantage of steel over wrought-iron.

JULY.

4th year.

1. A rough plane is inclined to the horizon at an angle of 60°; find (1) the magnitude of the force parallel to the plane; (2) the magnitude and direction of the least force which will prevent a mass of 100 lbs. from sliding down the plane, the coefficient of friction being $\frac{1}{\sqrt{3}}$.

2. The crown of Hiero with an equal weight of gold and an equal weight of silver were all weighed in water; the crown was found to lose $\frac{1}{11}$, the gold $\frac{4}{77}$, and the silver $\frac{3}{21}$ of the common weight. In what proportion were the gold and silver mixed in the crown?

3. Account for the weakening of the current in a Voltaic cell and show how the defects of this cell are removed in a Daniell's cell, giving a complete description of a Daniell's cell.

4. Describe the air thermometer. What is absolute temperature on the air thermometer. Show that the product of the volume and pressure of a gas is proportional to its absolute temperature.

5. (*a*) Determine the scale, expressed as so many inches to a mile, used in plotting a map upon which one square inch represents 40 acres,

or (*b*) A scale of bighas is attached to a certain map: the distance between two points known to be 3·5 bighas is represented on

this map by 5·25 inches. Show how to construct the corresponding scale of yards. One bigha = 120 feet.

6. Explain the effects of the earth's curvature and of terrestrial refraction upon level-readings.

7. A survey having been made, the area was determined to be 209 acres 3 roods 20 perches, but the 66-feet chain used was found to be $\frac{1}{4}$th of a link too long; find the true area in acres, roods and perches.

8. The centre lines of a railway meet at an angle of 144°26′, and the radius of the connecting curve is 3,498 feet. Calculate (1) tangent length, (2) length of curve, (3) angle at circumference for 100 feet chord. Nat. tangent 17°47′ = ·320744.

9. Draw the stress diagram of a queen post truss, when the pressure acts normal to one rafter. Also show which bar is unstrained.

10. A reservoir dam: its tallest part is 30 feet high, is 5 feet wide at top, and 10 feet at bottom, vertical face is towards water side. Find the greatest depth of water that can be just let to stand against the wall, weight of masonry being 125lbs. per cubic foot.

11. Find the greatest bending moment and shearing force of a 30 feet bridge at 6 feet from one of the abutments. The bridge is loaded with a steady uniform load of $\frac{1}{2}$ ton per foot run and moving load of one ton per foot run.

12. A roof 18′ × 18′ weighing 120lbs. per square foot is to be carried over five teakwood beams. Find the scantling of the beam, $b : d = 1 : \sqrt{2}$; $p_b = 750$.

3rd year.

1. How did Joule prove that gases do not lose heat on expanding unless they do mechanical work?

2. Draw Newcomen's steam-engine, and explain the principle on which it works. Describe briefly the nature of Watt's improvements on this engine.

3. What proportion of iron is there in 100lbs. of the compound Fe S.?

What are the various ores from which iron is extracted? Mention its properties and modifications.

4. Describe the manufacture of iron, distinguishing between wrought-iron, cast-iron and steel.

5. Show how to graduate a common steel yard?

If the fulcrum divides the beam, supposed uniform, in the ratio 3 to 1, and the weight of the beam be equal to the moveable weight, show that the greatest weight which can be weighed is four times the moveable weight.

6. In the 3rd system of pulleys, if there be *n moveable* pulleys, find the ratio of P to W.

7. In the 2nd system of pulleys find the number of pulleys in the lower block if P = 12 stone and W = 18 cwt.

8. A railway train weighing 30 tons is drawn up an inclined plane 1 in 60 by means of a rope of a stationary engine, find what number of lbs. at least the rope should be able to support.

9. Find log 390974, and also find the angle of which the sine is ·96. What is the logarithmic sine of the same angle ?

10. A point is reached where it is necessary to deflect the centre line through an angle 29°44′. It is to be joined by a 2° curve (radius = 2865); the chainage at the apex is found to be 15,877 feet from the initial starting point. Find the tangent length of the first odd distance.

11. Draw a traverse table and explain how it will be filled in ?

12. Describe the use of a plane table to fill in the details of a trigonometrical survey. Explain how the same may be used without a compass needle.

2nd year.

1. Submit the estimate with plan of house No. 2, which was done in class during last month.

2. Give brief descriptions of the two classes of lime kilns and the methods of using them. Which sort of lime kiln is generally used in Bengal ?

3. What do the black figures and red figures represent in Bidder's earthwork tables, and how are they obtained ? How are the contents of an earthwork found from the tables ? Explain also the method of finding the areas of side slopes from the tables.

4. Given log 25 = 1·3979400. Find log $(\cdot 064)^{\frac{1}{5}\frac{1}{7}}$

5. Given log 73335 = 4·8653113,
log 73336 = 4·8653172. Find log ·007333533.

6. Given cos 32° 31′ = ·8432351,
cos 32° 32′ = ·8430787. Find the angle of which the cosine is 8432.

7. Find the weight of a hexagonal wrought-iron nut : side of hexagon = 1½ inches, height of nut = 1½ inches, diameter of cylindrical hole = 1½ inches, weight of 1 cubic inch of wrought-iron = ·271lbs. (screw thread cuts are not to be taken into consideration).

8. If 30 cubic inches of gunpowder weigh 1lb., find the inside diameter of a hollow sphere which will hold 11lbs.

9. Describe two methods of preparing hydrochloric acid gas. To what extent is it soluble in water ? How can we show that the gas combines with water ?

10. When, and by whom, was iodine discovered ? State its appearance and properties. How would you detect a minute trace of iodine in solution ?

11. Show how the allotropic modifications of sulphur may be obtained. Give the specific gravity of each modification, and briefly describe its properties. Distinguish between the bleaching action of SO_2 and H_2S.

12. Show how sulphuric acid may be used to separate the principal metals into groups. Give the equations, showing the reactions between sulphuric acid and iron, copper, gold. Explain why the strong acid will not attack zinc freely. Would you use strong or dilute acid with mercury? If strong acid, explain the action in this case.

1st year.

Solve the equations—

1. $9x - 115 - 5z = 7y + 4z - 6x = 0$; $x^3 + y^3 + z^3 = 288$.

2. $\sqrt{x^2 + 5x - 6} - x = (x + 2)^2 - 12$.

3. Divide 111 into three parts so that the products of each pair may be in the proportion of 4, 5, and 6.

4. Simplify $\frac{2 - \sqrt{3}}{2 + \sqrt{3}} + \frac{1 + \sqrt{2}}{1 - \sqrt{2}} + \frac{1}{1 - \sqrt{3} + \sqrt{2}}$; and divide ·0065 by ·035.

5. A man sells £2,000, 4 per cent. stock at 90, and buys 6 per cent. railway shares at 50 a share, the original value of which was £40. Find the change in his income.

6. The sides of a triangle are 15, 16 and 17 feet. Find the radius of the inscribed circle.

7. Find the area of the quadrilateral ABCD from the following data :—

AB = BC; AD = 15′; DC = 36′; $\angle B = 60°$; $\angle D = 90°$.

8. Equiangular triangles are similar.

9. ABC is a triangle; AB is trisected at D and E, and AC is trisected at F and G; show that DF is parallel to and $\frac{1}{3}$ of BC.

10. How is iron extracted from its ores?

11. Why is white lead used in painting? What are its defects, and how are they overcome?

12. What precautions would you take in the construction of a wall?

APPRENTICE DEPARTMENT.

ANNUAL EXAMINATION.

1st, 2nd, and 3rd years.

ARITHMETIC AND ALGEBRA.

January 1891.

1. (*a*) Simplify $\frac{\frac{1}{4}+\frac{2}{3}}{4-\frac{5}{9}\text{ of }5\frac{1}{2}} \div \frac{\frac{2}{5}+3\frac{3}{5}}{\frac{7}{9}\text{ of }4\frac{1}{2}-1\frac{1}{3}}$; (*b*) 2·17 ÷ 031.

2. Find the value of ·025̇ of £4-10*s.* + $\frac{\cdot 49}{70}$ of £12-10*s.*

3. Extract the square root of 3·4, and find the value of $\frac{\sqrt{6}+2}{\sqrt{6}+1}$ to two places of decimals.

4. If 35 men can earn Rs. 141-4 annas in 18 days, how much can 84 men earn in 24 days?

5. A room is 38 feet long, 22 feet 6 inches broad, and 18 feet 9 inches high, and has 6 doors, each measuring 12 feet by 5 feet; find the cost of plastering the walls at 3 annas a square yard.

6. 97,920 rupees are invested in the 4 per cents. at 102; find the net annual income after deducting an income-tax of $3\frac{1}{8}$ per cent.

7. (*a*) Resolve x^2-4y^2 and x^6-35x^3+216 into elementary rational factors.

Extract the square root of $4x^4+12x^3+5x^2-6x+1$.

8. Solve the following equations:—

(*a*) $(x-7)(x-4)+(2x-3)(x-5)=43$.

(*b*) $x^2-y^2=5$, $2y^2-xy=2$, OR $x+y+z=\frac{ax+by}{cz}=\frac{cz+ax}{by}=\frac{by+cz}{az}$.

9. If x varies as y^2 and $x=2$ when $y=3$, find the value of x when $y=4\frac{1}{2}$.

10. Sum (*a*) $\frac{2}{4}+\frac{1}{2}+\frac{1}{3}+$ &c., to infinity.

(*b*) $9^2+10^2+11^2+12^2+$ &c., to 12 terms.

GEOMETRY.

1st, 2nd, and 3rd years.

1. (*a*) Name and explain the different parts of which a proposition consists

(*b*) Define the following terms:—Plane surface, a quadrilateral, rhombus, gnomon, similar figures, complements, duplicate ratio and supplementary angle.

2. The opposite sides and angles of a parallelogram are equal to one another, and each diagonal bisects the parallelogram.

3. If two sides of a quadrilateral are parallel, and the remaining two sides equal but not parallel, show that the opposite angles are supplementary, also that the diagonals are equal.

4. If a straight line is divided into any two parts, the sum of the squares on the whole line and on one of the parts is equal to twice the rectangle contained by the whole and that part, together with the square on the other part.

5. If a pair of opposite angles of a quadrilateral are together equal to two right angles, its vertices are concyclic, *i.e.*, a circle can be described about it.

6. Parallelograms which are equal in area, and which have one angle of the one equal to one angle of the other, have their sides about the equal angles reciprocally proportional. Enunciate and prove the converse of it.

MENSURATION.

1st, 2nd, and 3rd years.

1. The chord of an arc is 49 feet and the chord of half the arc is 25 feet, find the diameter of the circle.

2. From a plank 14 feet 3 inches long a square yard is to be sawed off lengthwise; at what distance from the edge must the line be struck?

3. A rectangular grass plot, the sides of which are as 2 : 3, cost £14·8*s.* for turfing at the rate of 4*d.* per square yard; find the lengths of its sides.

4. Find the side of a regular 12-sided figure inscribed in a circle of 1 foot diameter.

5. The diagonal of a cube is 30 inches. What is the solid content?

6. A conical sugar loaf is to be divided among three persons by means of sections parallel to the base; what must be the length or thickness of each part, the height of the cone being 20 inches?

7. The height of an embankment is 4 feet, the width of the road is 40 feet, slope of the ground is 3 to 1, side slope 2 to 1; find the side widths.

8. If a heavy sphere, whose diameter is 4 inches, be put into a conical glass, full of water, whose diameter at the rim is 5 inches and the depth 6 inches, how much of the water will run over?

N. B.—

	Geometry.	*Mensuration.*
1st year ...	Whole paper	... 1, 2, 3, 4.
2nd „ ...	Ditto	... 4 5, 6, 7.
3rd „ ...	Ditto	... 5, 6, 7, 8.

TRIGONOMETRY.

2nd and 3rd years.

1. Find the C. M. of $11° - 15'$, and convert $\frac{\pi}{8}$ C. M. and $\frac{1}{3}$ C. M. into degrees.

2. Prove that $\sin (A - B) = \sin A \cos B - \cos A \sin B$ when A and B are acute and A is greater than B.

Given $\sin A = \frac{12}{13}$ and $\sin B = \frac{4}{5}$, find $\sin (A - B)$.

3 Given $\tan 45 = 1$ and $\tan 30 = \frac{1}{\sqrt{3}}$, show that $\tan 15 = 2 - \sqrt{3}$.

Show that $\tan A + \tan B = \frac{\sin (A + B)}{\cos A \cos B}$.

4. Given $\sin A = \cdot 8$ and A less than a right angle, find $\cos A$, $\cos (270 + A)$, and $\sin 2A$.

5. Show that—

(a) $\sin 5\theta + \sin 3\theta = 2 \sin 4\theta \cos \theta$.

(b) Solve $\sin \theta + \cos \theta = \sqrt{2}$.

6. Show that in a triangle $\tan \frac{A - B}{2} = \frac{a - b}{a + b} \cot \frac{C}{2}$.

7. Given that $a = 1$, $b = \sqrt{3} - 1$, $\angle C = 60°$; solve the triangle.

8. Given $\angle A = 30°$, $\angle B = 45°$, $a = 2\sqrt{2}$; solve the triangle.

9. (a) Prove that $\sin (A + B) \sin (A - B) = \sin^2 A - \sin^2 B$, $\sin 20 + \sin 40 = \sin 80$. } For the 2nd year only.

or (b) Find L sin 30 and the angle of which the tangent is 2·5. Express $\log (\cdot 098)^{\frac{1}{8}}$ in terms of $\log 7$ and $\log 2$. } For the 3rd year only.

STATICS AND HYDROSTATICS.

3rd year.

1. State the propositions called the triangle of forces and the polygon of forces.

2. What do you mean by the centre of parallel forces?

A straight horizontal rod of weight W is marked with five equal divisions. At these divisions act perpendicular to the rod forces equal to W, 2W, 3W, 4W, 5W, respectively. Find the centre of force.

3. If the weight of each of a system of heavy particles be multiplied into the square of the distance of the particle from a given point, the sum of the products is least when the given point is the centre of gravity of the system.

4. A uniform board in the form of an equilateral triangle has particles of the same weight as the triangle at two of its corners. Find the centre of gravity of the whole.

5 Find a formula for the third system of pullies, taking into account the weight of the pullies.

6. One end of a uniform beam is on a smooth inclined plane, and the other end on a rough horizontal plane. Find the limiting positions of equilibrium.

7. State the principle of virtual velocities, and apply it to the case of the screw.

8. Define a fluid. What do you mean by pressure at a point?

9. Find in pounds weight the pressure on the upper surface of a horizontal square board, each side of which is 2 inches, placed in water at a depth of 10 feet, taking into account the pressure of the air.

10. Equal volumes of three liquids whose specific gravities are as 1, 2, 3 are mixed. Equal weights of the same three liquids are mixed. Compare the specific gravities of the two mixtures.

CHEMISTRY.

2nd year.

1. Describe one method of preparing hydrogen.

2. How would you ascertain the composition of water by electrolysis?

3. Calculate the percentage composition of nitric acid.

4. State some facts illustrating the law of multiple proportions.

5. Describe and explain Carré's ammonia ice-making machine.

6. What have you to say with respect to the structure of a candle-flame.

7. How would you prepare chlorine?

8. State the physical and chemical properties of iodine.

3rd Year.

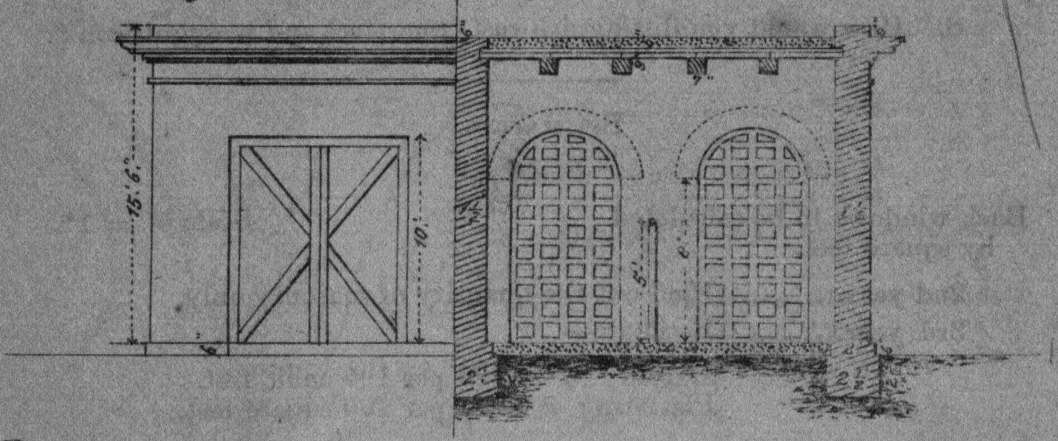
1. Illustrate by some examples what is meant by the term quantivalence.

2. Describe and explain Carré's sulphuric acid ice-making machine.

3. How did Cavendish investigate the composition of water?

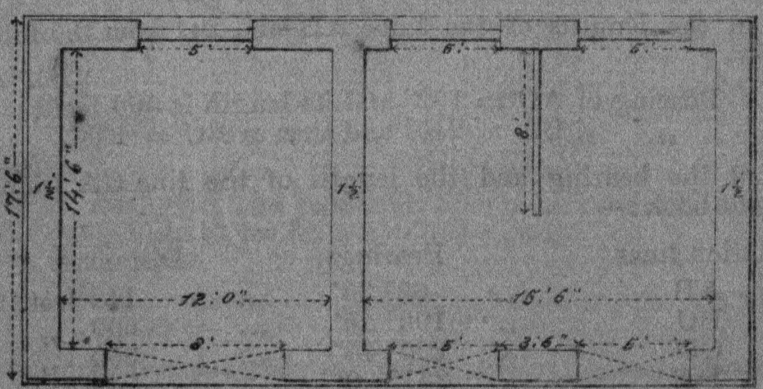
PLAN HALF ELEVATION & HALF SECTION
of
STABLE.

Half Elevation & Half Section.



Beams ..... 9"×7"
Burgahs ..... 2"×3"
Battens for Door ..... 3"×3"
Backdoor to be Calculated by Square feet
Partition Plank thick ..... 1"

Stable



4. Calculate the percentage composition of anhydrous cupric sulphate.

5. Describe the Dutch method of manufacturing white lead.

6. Write down the atomic weights of twenty of the more common elements.

7. Give a sketch of the manufacture of pig-iron.

8. How would you distinguish cast-iron, steel and wrought-iron ?

ESTIMATING.

Stable.

Back windows to be calculated by square feet. Scale 5′ = 1″.

2nd year.....Find out the quantity of masonry only.

3rd year.....Estimate—

Masonry @ Rs. 20 per 100 cubic feet.
Plastering @ Rs. 5 per 100 square feet.

SURVEYING.

1st, 2nd and 3rd years.

1. Draw the following scales :—

(i). 60 inches to a mile, showing feet, simple scale.
(ii). 2 yards = 1″, showing yards, feet and inches, diagonal scale.

2. By measuring with a Gunter's chain 2″ too short, the length of a canal is found to be 10 miles ; find its true length.

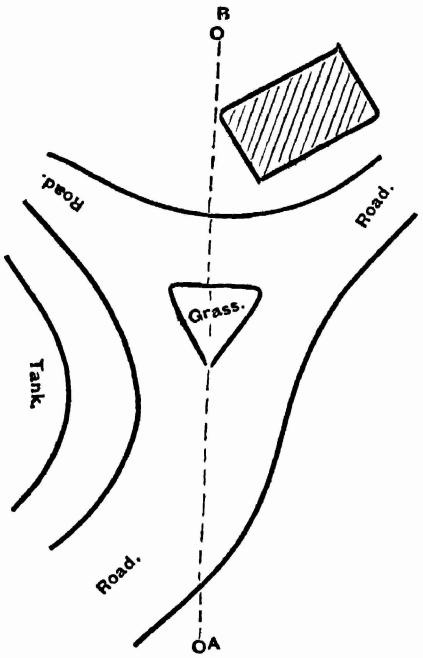
3. Find the lengths of the lines AB and BC from the following data :—

Bearing of AC = 102° and its length is 500 feet.
„ „ BA = 215° and that of BC = 158°.

4. Find the bearing and the length of the line GA from the following field-book :—

Station lines.		Bearings.		Distances.
AB	...	68° 30′	...	113 feet.
BC	...	100° 45′	...	600 „
CD	...	220° 45′	...	300 „
DE	...	341° 0′	...	48 „
EF	...	273° 30′	...	345 „
FG	...	264° 30′	...	214 „
GA	...	...	...	...

5. Give the main points to be considered in fixing stations of a compass-survey.



6. The marginal figure is a rough plan of a place to be surveyed. Write a field-book, figuring the offsets you would take that the entire plot might be fully represented in the plan. The station line AB may be approximately taken to be about 300 feet.

7. What do you understand by the term "error for curvature?" How does it effect apparent level? Why in ordinary levelling is it not taken into account, even in levelling long lines?

Back sight.	Intermediate sight.	Fore sight.	Rise.	Fall.	Reduced level.
3·41	...	...	...	...	...
...	2·19	...	...	...	
...	4·26	...	...	...	
...	5·27	...	...	...	
2·15	...	4·09	...	...	97·37
3·09	.	1·97	...	...	...
..	4·25	...	...	..	...
...	1·06	...	...	...	...
...	2·91	...	...	...	..
...	...	6·28	...	...	...

8. Fill up the marginal level book.

9. Describe the method of observing an angle with the theodolite.

10. A road runs a mile and-a-half straight, and then deviates 60° towards the right; this angle is to be rounded off by a curve of 2,000 feet radius. Calculate the tangent lengths, 1st and the 2nd odd-distances, secant points, and the tangential angle for a 100 feet chord.

N.B.—1st-year students are not to answer the 7th, 8th, 9th and the 10th questions.

2nd-year students are not to answer the 1st, 2nd, 9th and 10th questions.

3rd-year students are not to answer the 1st, 2nd, 3rd and 8th questions.

PHYSICS.

3rd-year.

1. Write some of your workshop experience in connection with expansion and contraction by heat.

2. What metals are used in the manufacture of a boiler and steam-engine? State the reasons why one or the other metal is used.

3. Under what circumstances have you observed in the workshops that the energy of mechanical motion may be converted into heat.

4. How did Joule determine the thermal equivalent of mechanical work?

5. What is the scientific meaning of the term conductivity? Arrange the following metals in their order of conductivity:—Bismuth, silver, iron, brass, copper.

6. What is the greatest proportion of heat that can possibly be utilised in a heat-engine? State, if possible, what bearing this has on the subject of compound steam-engines.

7. Write down the following physical constants:—

(1) heat of evaporation of water at 100° C;
(2) the mechanical equivalent of heat;
(3) heat of liquifaction of ice;
(4) heat of combustion of pure carbon.

ENGINEERING.

1st, 2nd, and 3rd-years.

1. Describe the process of making Victoria stones and the Madras process of quarrying granite.

2. Sketch an ordinary brick mould, giving measurements for a brick 10″ × 4½″ × 2¾″, and also sketch a mould suitable for moulding ornamental bricks.

3. What are the advantages of a sindth or flame kiln; what is slop moulding?

4. Name the different kinds of tiles used for engineering purposes. How are drain tiles made?

5. Explain the terms :—Caustic lime, gypsum, setting the kiln, grouting, boton, heart-wood, blister steel, case hardening, distemper, mastico.

6. Describe the different ways of slaking lime. What is slaked lime?

7. What are the differences in the qualities and structure of cast-iron, wrought-iron and steel? How is iron found in nature?

8. What is the object of seasoning timber, and how are timbers protected from 1st, moisture; 2nd, internal decay?

9. Describe *briefly* the different processes through which an iron ore is to be passed before wrought iron is obtained, as given in your book.

10. What are the requisites to be attended to on applying mortar? What is hydraulic mortar?

11. When a building is to be built on sloping ground, explain how the foundations should be made so as to avoid a waste of masonry and illustrate your explanation by a sketch.

12. What is the main cause of slips in earth-works, and how they are to be prevented?

13. What are English and Flemish bonds? Explain your answers by sketches.

14. Explain clearly what you understand by well foundation and Pierre Pirdice foundation. Where are they used?

15. Give a skeleton sketch of a queen post truss for a span of 40 feet, and write the names of the different parts.

16. Explain the nature and use of a relieving arch Explain the terms (1) extrados, (2) intrados, (3) springings, (4) span of an arch, (5) crown of an arch, (6) haunches, (7) spandrils.

N B.—1st year will answer from 1 to 10; 3rd-year 5 and 7 to 16, 2nd-year 5 to 14.

Drawing.

1st, 2nd and 3rd-years.

1. Construct a scale of 1½ inches = 1 foot, and by taking measurements from this scale construct an oblong of sides 2′-3½″ × 1′-8″.

2. The major diameter of an ellipse is 3 inches, and the minor diameter is 2 inches. Draw the curve of the ellipse.

3. Construct a half-inch decimal diagonal scale, and show on it a length of 2·225 inches.

4. Write the 1st thirteen letters of the English alphabet in ½ inch *block type* and the last thirteen in ¼ inch *italics*—all in free hand.

5. Within a regular pentagon of 1½ inch sides inscribe a square. What is the length of a side of the square?

6. Explain by scale of chords how to draw an angle of 55°. Draw a circle which shall touch both lines of an angle of 55° and shall pass through a given point P.

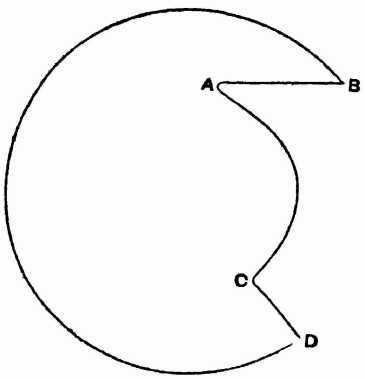
7. Construct an *oval* of 2 inches in width.

8. Show a general method of constructing all regular polygons (say by a heptagon).

9. A cube of 2½ inches side is surmounted by a square pyramid formed of a base and 4 equilateral triangles of 3½ inches sides. The pyramid is so placed on the cube that the diagonals of the base of the

pyramid coincide with those of the top of the cube. Find the plan and elevation of the object when one diagonal of the base of the cube is parallel to the vertical plane and makes an angle of 40° with the horizontal plane.

10. Find the elevation of the sphere whose right hand side is cut vertically as shown on the annexed plan. The line AB is parallel to the vertical plane, the centre of arc AC coincides with the centre of the sphere, CD makes an angle with the vertical plane. Copy the size given.



N.B.—1st year will answer from 1 to 8; 2nd and 3rd years from 3 to 10.

APPRENTICE DEPARTMENT.

ANNUAL EXAMINATION, AUGUST 1891.

1st, 2nd and 3rd years.

ARITHMETIC AND ALGEBRA.

1st year will omit No. 12.
2nd and 3rd years will omit No. 10.

1. Simplify $\dfrac{1\frac{1}{4} \text{ of } 1\frac{4}{5} - \frac{5}{3} \text{ of } 1\frac{1}{5}}{3\frac{1}{2} + \frac{4\frac{1}{4}}{11\frac{1}{3}}} \div \frac{2}{17}$

2. Divide the sum of 26·82639 and 366·59515 by the difference between ·064 and 7·923. Express the difference between 2·068 and 1·904 as a vulgar fraction in its lowest terms.

3. Shew that all vulgar fractions are reducible to decimals which must be either exact or recurring. How can you determine whether any given fraction will reduce to an exact or recurring decimal?
Convert $\frac{9}{128}$ and $\frac{7}{13000}$ into decimals.

4. Find the square roots of (*a*) 25070049, (*b*) ·000025070049, (*c*) ·00025070049. Express £45·15 + 6·625*s.* + 4·25*d.* as the decimal of £5.

5. I invest £1,125 at simple interest, and at the end of 7 years and 4 months the principal and interest together amount to £1,413-5-0. At what rate per cent. is the interest paid?

6. A person disposing of goods for £45-10-0 loses 9 per cent.; for what should he have sold them to gain 7 per cent.?

7. Simplify (*a*) $\dfrac{1 + 3x - 24x^2 + 8x^4}{2x^2 + 3x - 1}$.

(*b*) $\dfrac{x^3 + 4x^2 - 8x + 24}{x^4 - x^3 + 8x - 8}$.

(*c*) $\dfrac{x^2 - 25y^2}{x^2 + 3xy - 10y^2} \times \dfrac{x^2 - 4y^2}{x^2 - 3xy - 10y^2}$.

8. Solve (*a*) $\dfrac{1}{x+2} + \dfrac{1}{x+10} = \dfrac{1}{x+4} + \dfrac{1}{x+8}$.

(*b*) $(b - c)\,x^2 + (c - a)\,x + (a - b) = 0$.

(*c*) $\left.\begin{aligned}(a + b)\,x + (a - b)\,y &= 2ac\\ (b + c)\,x + (b - c)\,y &= 2bc\end{aligned}\right\}$

9. If $a : b :: c : d$, shew that $(a^2 + c^2)(b^2 + d^2) = (ab + cd)^2)$.

Two numbers are in the ratio of 5 : 8; if 9 be added to each they are in the ratio of 8 : 11. Find the numbers.

10 Find the square root of $(2x + 1)(2x + 3)(2x + 5)(2x + 7) + 16$.

11. Find the sides of a rectangle whose area is unaltered if its length be increased by 4 feet while its breadth is diminished by 3 feet; and which loses $\frac{1}{5}$ of its area if its length be increased by 16 feet while its breadth is diminished by 10 feet.

*12. Find the 7th term of $(a - 2x)^{12}$ and shew that the middle term of $(1 + x)^{2n}$ is $\frac{1 \cdot 3 \, 5 \cdot \cdot \cdot (2n - 1)}{\lfloor n} \cdot (2x)$.

Geometry and Mensuration.

1*st year.*

1. Define oblong, trapezium, right angle, and gnomon; write down the three postulates.

2. The opposite sides and angles of a parallelogram are equal to one another, and the diameter bisects the parallelogram, that is, divides into two equal parts.

3. In every triangle, the square on the side subtending an acute angle, is less than the squares on the sides containing that angle, by twice the rectangle contained by either of these sides, and the straight line intercepted between the perpendicular let fall on it and the acute angle.

4. The sum of the squares on the sides of a triangle is equal to twice the square on half the base, together with twice the square on the straight line which joins the vertex to the middle point of the base.

5. The angles in the same segment are equal to one another.

6. Equal parallelograms which have one angle of the one equal to one angle of the other, have their sides about the equal angles reciprocally proportional, and prove the converse of it also.

7. The length of a chord is 150 feet and its distance from the centre is 308 feet; find the diameter?

8. A gravel walk of uniform breadth is made round a rectangular grass plot, the sides of which are 20 yards and 30 yards; find the breadth of the walk if its area be $\frac{3}{10}$ths of that of the grass plot.

9. The parallel sides of a trapezoid are 55 feet, and 77 feet and the other sides are 25 feet and 31 feet; find the area.

10. The length of a room is double the breadth, the cost of colouring the ceiling at $4\frac{1}{2}d$ per square yard is £2 12*s.* 1*d.*, and the cost of painting the four walls at 2*s.* 4*d.* per square yard is £35; find the height of the room.

2nd and 3rd years.

Answer questions 1st to 6th both inclusive, 8th, 10th and

11. The height of a solid six-inch cube is diminished by pressure to $5\frac{5}{8}$ inch; supposing the lateral expansion uniform throughout the mass, what will be the dimension of the new base of this solid?

12. A solid is composed of a cone and hemisphere on opposite sides of the circular base, the diameter of which is 2 feet, and the vertical angle of the cone is a right angle; find the volume of the whole.

TRIGONOMETRY.

2nd year.

1. If half a right angle be the unit of angular measurement, express the angles whose measures are $\frac{3}{2}$, 4, π, $(4n + \frac{1}{3})$, in (1) degrees, in (2) units of circular measure.

2. Trace the changes in the sign and magnitude of the cotangent of an angle as the angle increases from 0° to 360°.

3. Prove the following relations:—

(*a*) $\text{Sin}^2 \frac{3}{2}\pi + \cos^2 \frac{3}{2}\pi = 1$; $\text{cosec}^2 \text{A.} = 1 + \cot^2 \text{A.}$

(*b*) $\text{Cos } x = \dfrac{\cot x}{\sqrt{(1 + \cot^2 x)}}$; $(\text{cosec } \theta - \cot \theta)^2 = \dfrac{1 - \cos \theta}{1 + \cos \theta}$.

(*c*) $\tan (180 + \text{A}) = \tan \text{A}$.

4. Write down all the trigonometrical ratios of an angle and its complement, and also of its supplement.

5. Solve the following equations:—

(*a*) $\text{Sin } \theta + \cos \theta = \sqrt{2}$.

(*b*) $\tan \theta + \cot \theta = 2$.

(*c*) $4 \sec^2 \theta - 7 \tan^2 \theta = 3$.

6. Find the logs of 76·23 and $\frac{3}{5}\frac{3}{9}$, given $\log 3 = \cdot 4771213$, $\log 7 = \cdot 8450980$, $\log 11 = 1 \cdot 0413927$.

7. Prove the formula $\cos (\text{A} + \text{B}) = \cos \text{A} \cos \text{B} - \sin \text{A} \sin \text{B}$ where A and B are both greater than a right angle.

8. Prove the following identities:—

(*a*) $\dfrac{1 - \cos \text{A}}{1 + \cos \text{A}} = \tan^2 \dfrac{\text{A}}{2}$.

(*b*) $\sin 3\text{A} = 3 \sin \text{A} - 4 \sin^3 \text{A}$.

(*c*) $\dfrac{\text{cosec } 2\text{A} - \cot 2\text{A}}{\text{cosec } 2\text{A} + \cot 2\text{A}} = \tan^2 \text{A}$.

9. Find the values of tan 15° and sin 18°, cos 120.

10. Prove the following formula:—

(*a*) $\sin P + \sin Q = 2 \sin \frac{P + Q}{2} \cos \frac{P - Q}{2}$.

(*b*) $\cos Q - \cos P = 2 \sin \frac{P - Q}{2} \sin \frac{P + Q}{2}$,

$$\tan (A - B) = \frac{\tan A - \tan B}{1 + \tan A \tan B}.$$

3rd year.

Answer questions 1, 4, 5, 7, and 9, of the above paper, and

11. Find logarithm 76·23 and $_5\frac{3}{10}$, given log 3 = ·4771213, log 7 = ·8450980, log 11 = 1·0413927.

12. Show that in a triangle $c = a \cos B + b \cos A$ and $\frac{\sin A}{a} = \frac{\sin B}{b} = \frac{\sin C}{c}$.

13. (*a*) Show that $\tan \frac{A - B}{2} = \frac{a - b}{a + b} \cot \frac{C}{2}$.

(*b*) Find an expression for the area of a triangle in terms of the three sides of the triangle.

14. If A, B, C be the angles of a triangle, prove the following relations:—

$$\text{Sin } A + \sin B - \sin C = 4 \sin \frac{A}{2} \sin \frac{B}{2} \cos \frac{C}{2}.$$

In any triangle prove $\tan A = \frac{a \sin C}{b - a \cos C}$.

15. Find the angles B and C of a triangle, given $b = 50$, $c = 30$, $A = 30°$.

log 2 = ·3010300. L tan 43° = 9·9696559, L tan 43° 1′ = 9·9699091, L cot 15° = 10·5719475.

Statics.

3rd year.

1. What do you mean by the resultant of two forces?

Prove the formula $R^2 = P^2 + Q^2 + 2PQ \cos a$.

2. State the triangle of forces, and prove it, assuming the parallelogram of forces.

3. Find the magnitude and point of action of the resultant of two parallel forces acting in the same direction.

4. What do you mean by a couple, and the moment of a couple?

Prove that two unlike couples in the same plane will balance each other if their moments are equal.

5. Define the centre of gravity of a body. Describe and explain a method of finding experimentally the centre of gravity of a body.

6. On one side of a square is described an equilateral triangle.

Find the centre of gravity of the whole.

7. If two weights balance each other on a straight lever in any one position inclined to the vertical, they will balance each other in any other position of the lever.

8. Find the relation between the power and the weight in the 3rd system of pulleys.

9. A given weight rests on an inclined plane, and is kept from slipping by a force acting horizontally. Find the force and the pressure on the plane.

10. A uniform rod 5lbs. weight hangs from a hinge at its upper end, and is kept at an angle of 45° to the vertical by a force acting horizontally at its lower end. Find this force.

CHEMISTRY.

2nd and 3rd years.

The 3rd year will omit the first three questions; the 2nd year will omit the last three.

1. Describe and illustrate with diagrams two processes for the production of oxygen gas, giving equations.

2. How much hydrogen by weight could 20 grammes of zinc liberate from sulphuric acid? If 11·7 grammes of potassium were thrown on water, what would be liberated, and how much?

3. How would you distinguish between oxygen, hydrogen, nitrogen, carbon monoxide, carbon dioxide, if belljars provided with stops cocks filled with each were placed before you?

4. Describe briefly one method of preparing *any five* of the following substances, and sketch the apparatus:—

(*a*) Nitrogen, (*b*) ammonia (*c*) carbon dioxide, (*d*) sulphuretted hydrogen, (*e*) silicic tetra-fluoride, (*f*) nitric acid, (*g*) phosphuretted hydrogen.

5 State the law of multiple proportions, and illustrate your statement by an example. State the other two fundamental laws of chemical combination.

6. Write down the molecular formulæ of the oxides, sulphates, nitrates, orthophosphates of hydrogen, copper, silver, calcium, iron, potassium

7. State the physical properties of carbon, chlorine, nitric acid, phosphorus, silica.

8. What is the chief ore of tin? Describe the process of reduction of the ore. Mention three important alloys of tin, giving the proportions of the metals employed.

9. Give the equations for the reactions when a current of sulphuretted hydrogen is passed through the following acid solutions; state whether or nor a precipitate is formed, and if so, give its colour:—

Manganous chloride, ferrous sulphate, ferric chloride, stannous chloride, antimonious chloride.

How would you detect the presence of a small quantity of a ferric salt in a ferrous solution?

10. Describe and illustrate with a diagram Marsh's test for antimony and arsenic. How can antimony and arsenic be distinguished?

Estimating.

Estimate in the following order:—

2nd year.

1. Foundation and plinth masonry.
2. Superstructure masonry to top of cornice only.
3. Flooring.
4. Flat terrace roofing.

3rd year.

1. Foundation and plinth masonry.
2. Superstructure masonry including parapet.
3. Flooring.
4. Flat roofing.
5. Sloped roofing of tiles.
6. Cornice in running feet.

Surveying.

2nd and 3rd years.

1. (*a*) How is a right angle laid on the ground by means of the chain only?

(*b*) In chaining, how would you avoid an obstacle in your line?

(*c*) What advantage has the Gunter's over the hundred-foot chain?

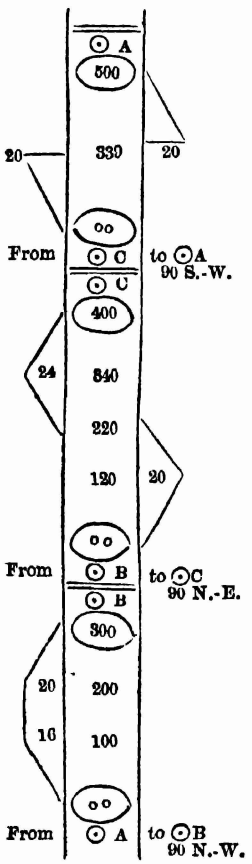
(*d*) How would you find the true length of a line which has been measured with an incorrect chain?

2. (*a*) What is the difference between "bearings" and "angles"? Find the acute angle between two lines whose bearings are 36° 45′ and 252° 15′.

(*b*) Write down the bearings corresponding to the following angles taken with a surveying compass:—N. 22°W., S. 39° W., N. 33°E., and S. 25°E.

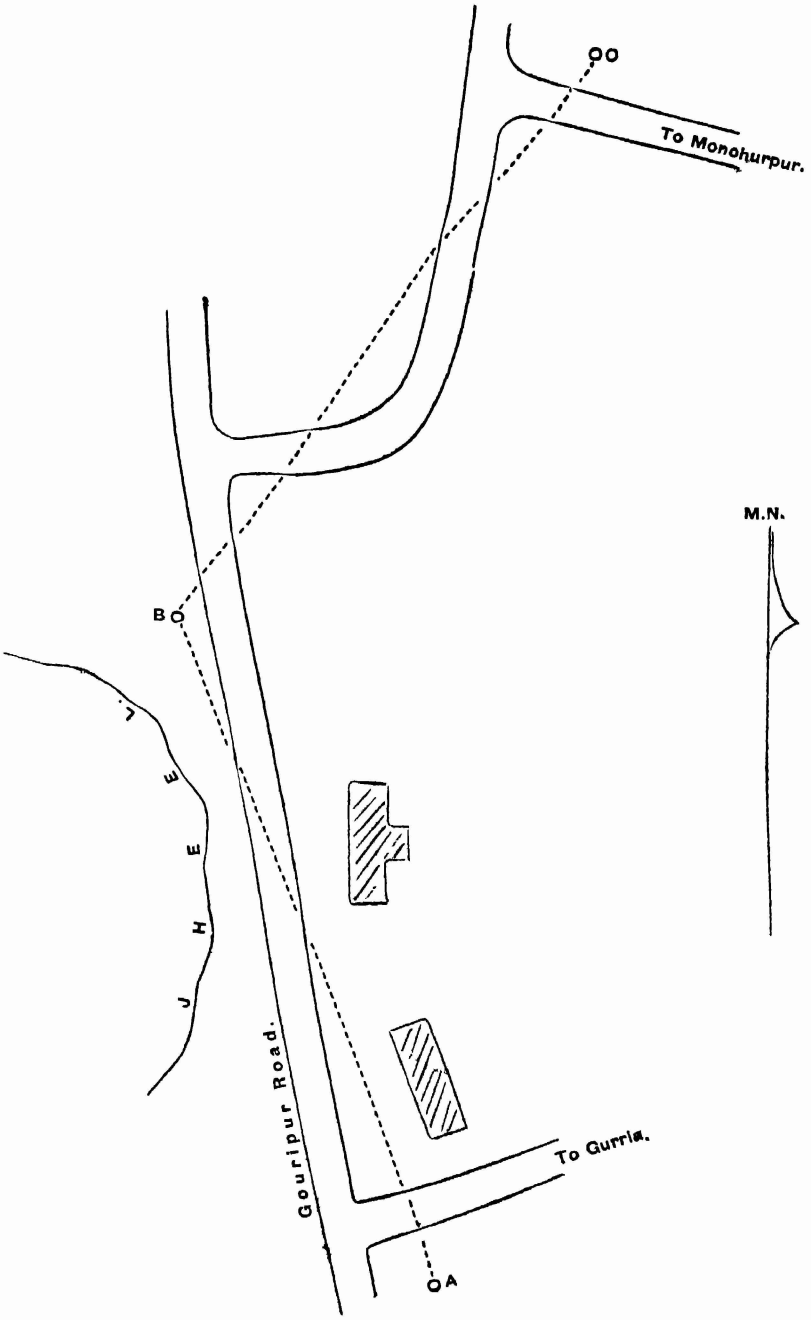
3. What are the main points of difference between the surveying and the prismatic compasses?

4. From the following field book of a chain survey, plot the field to scale 80 ft. = 1 inch, and calculate its area in acres:—



5. *A* and *B* are two fixed points in a survey; the bearing of *AB* is 26° 30′. From a point *C* the bearings of *A* and *B* are observed to be 265° and 330° respectively; show how would you fix the position of *C*.

6. Draw up neatly an imaginary field book of a compass survey from the accompanying sketch on which *AB*, *BC* represent the chain lines :—



7. How would you find the breadth of a river which is about a quarter of a mile broad?

For Third-year students only.

8. Reduce the accompanying page of a level book, and check your work.

Stations.	Back.	Intermediate.	Forward.	Distance.	Rise.	Fall.	Reduced levels.	Remarks.
1	5·21	...	...	0	...	...	...	On peg centre of proposed road.
	...	4·75	..	120	...	...	...	
	...	5·69	...	280	...	...	...	
	...	7·92	...	...	...	...	...	Highest water level of Hughli, 20th January 1891.
2	5·19	...	4·66	500	...	...	...	
	...	3·16	...	...	...	...	28·26	B. M. No. 34, G. T. Survey.
	...	6·79	...	680	...	...	...	Left bank of canal.
	...	12·28	...	705	...	...	...	Middle of do.
		6·27	..	730	...	...	...	Right bank of do.
3	3·26	...	4·57	900	...	...	...	
	...	4·19	...	1,100	...	...	...	
	...	5·28	...	1,250	...	...	...	
	...	...	5·55	1,400	...	...	...	On peg centre of road to village.

9. The horizontal wire of a level in perfect adjustment cuts two points *A* and *B*, distant respectively half a mile and one-fourth of a mile from the instrument; find the relative difference of level between the points.

10. Explain the terms:—"Bench marks," "Datum line," "Check levels" and "Reduced levels."

Third year will omit No. 3.

Physics.

3rd year.

1. How many degrees Fahrenheit are 45 degrees Centigrade? Tin melts at 235°C.; what is its melting point on the Fahrenheit scale? The temperature of a room is found to be 95°F.; what is the temperature on the Centigrade and on the Reaumur scale?

2. Linear expansion of copper between 0° and 100°C. = 0·001716; what is the volume in cubic centimetres at 30°C, of a cylinder of copper, the dimensions of which at 0°C. are the following—radius of base 10 cm., height 20 cm.

3. Explain what happens when a drop of water is allowed to fall on a horizontal clean plane plate of iron heated to redness.

4. One ounce of silver is strongly heated and then plunged into 10 oz. of water having a temperature of 25°C, after a short time the temperature of water and silver is 28°C.; what was the temperature of the silver just before it was plunged into the water (specific heat of silver =0·0557)?

5. What is heat? How would you prove that it is not a substance?

6. How does the water in a boiler get heated?

7. Sketch and describe an apparatus for the distillation of water.

8. If you put a pound of ice in 2 pounds of water at 90°C. and stir for some time, what is the final result?

9. What is meant by the following terms:—heat of liquefaction, atomic heat, thermal equivalent of work, conductivity, thermal unit, specific heat, regelation.

ENGINEERING.

1st, 2nd and 3rd years.

1. Give general descriptions of appearance and qualities of the following timbers:—Teak, sâl, sissu, and simal.

2. Why should trees be felled for timber at the end of autumn or in winter? Which is the hardest part of a tree (1) when it is growing, (2) when it has ceased growing and decay has commenced?

3 Describe the process of moulding bricks on tables and the method of drying table-moulded bricks.

4. What is the most convenient size for burnt bricks? State your reasons why bricks should not be made larger or smaller.

5. What is the principal point to be attended to in selecting the mixture for plaster? What is plaster?

6. Why should lime be used as fresh as possible? Why is pure lime not used for cementing bricks? How is mortar prepared in Bengal? Can you name any stone in which mortar is found naturally?

7. Describe the process of quarrying large masses of stone. What is meant by the line of least resistance?

8. Explain the terms:—Alloys, soldering, hard solder, soft solder, blast furnace. What is the composition of gun-metal?

9. How is cast-iron obtained from nature?

10. What precautions are generally taken to diminish the danger from unequal setting in building a masonry structure?

11. What is meant by side-widths in earth-work, and how are they set out? What preliminary operations are necessary before setting out side-widths?

12. Sketch a jham, and give a brief description of the method of using it. What is meant by iron tubular foundation?

13. Give neat sketches of joints (which will preserve the same breadth and depth throughout) for lengthening timbers subjected to (1) compression and (2) tension (*a*) when the pieces to be joined can be shortened, (*b*) when it is necessary to join the pieces without shortening. Give one sketch only for each. What is this mode of joining timbers termed?

14. What is "centre" in arching. In constructing centres what are the principal points to be attended to? Describe the most usual way of striking centres of large arches.

15. Describe the different sorts of pent roofs in use. What is meant by the pitch of a roof? Draw skeleton sketch of a king-post truss for 30 feet span, and name the different parts:—

N.B.—1st year will answer from 1 to 10.
2nd year ditto from 3 to 12.
3rd year ditto from 3 to 11 and 13 to 15.

Drawing.

1st year.

1. Print the following words in $\frac{1}{4}$ inch italics:—"Perseverance and a determination to succed ensure eventual success."

2. Draw the following scales:—

(1) One-eighth full size.

(2) One inch to two and-a-half feet.

(3) Three-quarter decimal diagonal — $\frac{1}{10}$ th and $\frac{1}{100}$ th.

3. Draw a triangle the sides being $2\frac{1}{4}$ inches, $3\frac{1}{2}$ inches, and 4 inches and (2) inscribe therein the largest square it will contain.

4. Draw a regular pentagon, the sides to be $1\frac{1}{4}$ inches, and calculate its angles.

5. Construct an isosceles triangle, equal in area to the above pentagon.

6. Draw the "cycloid," the generating circle being 2 inches diameter.

7. A cube of 2-inch side stands on the horizontal plane with four of its sides forming angles of 45° to the vertical plane. Draw its plan, elevation, and side elevation.

2nd year.

1. Draw the following scales:—

(1) One eighth full size.

(2) Two and-a-half feet to one inch.

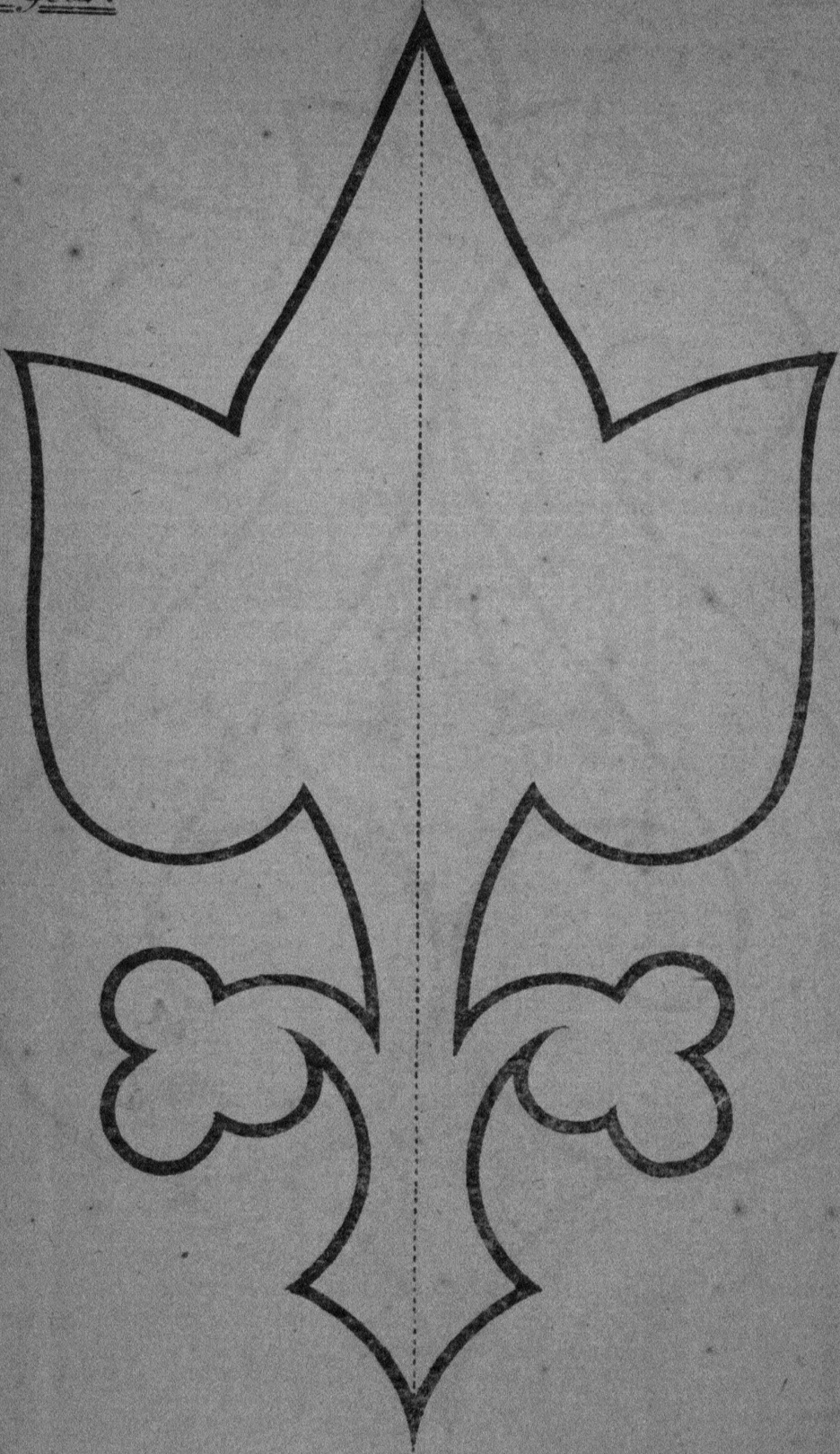
(3) $\frac{3}{4}$ inch decimal diagonal, $\frac{1}{10}$th and $\frac{1}{100}$th.

2. Draw a regular (1) pentagon and (2) heptagon, the sides of each to be 1 inch. and calculate their angles.

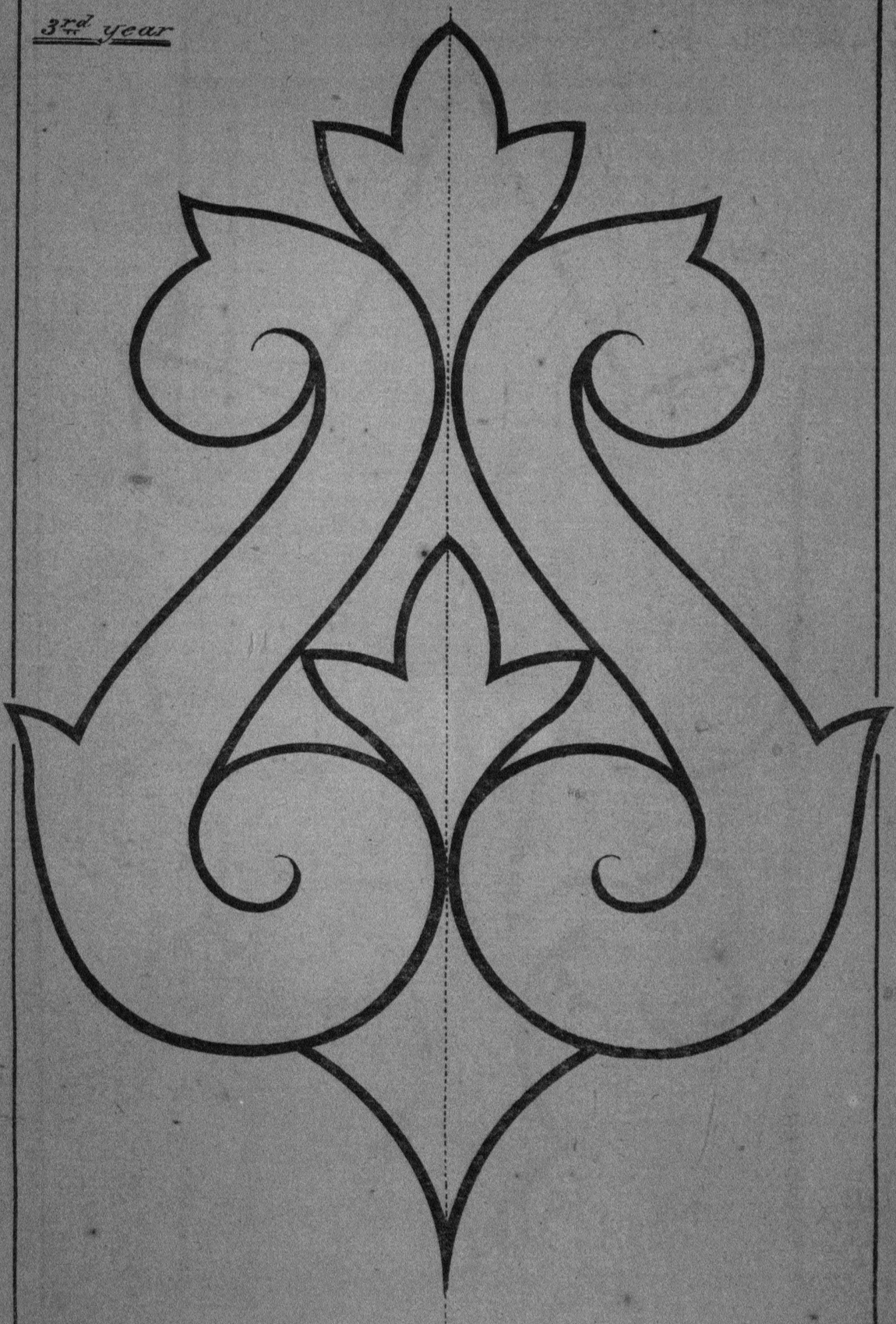
3. Construct an isosceles triangle equal in area to the pentagon, and an equilateral triangle equal in area to the above heptagon.

4. A cone of $3\frac{1}{2}$-inch base and 6-inch altitude is cut by a sectional plane at 45° to its axis. Draw section of the cone.

2nd year.



3rd year



5. Draw plan elevation and side elevation and section of a hexagonal nut, as ordinarily used in machinery, to fit a bolt $1\frac{1}{2}$ inch diameter, screwed with a right hand, V thread sizes optional.

6. When you have entirely finished with the above questions and your instruments, give up *all* your rulers, compasses, &c., &c., to the duftry, and then draw by free hand only the ornament in the copy supplied you, half size.

3rd year.

1. Draw the following scales:—

   (1) One-eighth full size.

   (2) Two and-a-half feet to one inch.

   (3) $\frac{3}{4}$ inch decimal diagonal, $\frac{1}{10}$th and $\frac{1}{100}$ lb.

2. Draw a regular (1) pentagon and (2) a heptagon, the sides of each to be one inch, and calculate their angles

3. Construct an isosceles triangle, equal in area to the above pentagon, and an equilateral triangle equal to the heptagon.

4. Draw plan, front and side elevations, and section of a hexagonal nut, as ordinarily used in machinery, to fit a bolt $1\frac{1}{2}$ diameter, screwed with a right hand V thread.

5. Draw a projection of the nut, one edge resting on the horizontal and at 15° to the vertical, and the lower surface of nut to be at an angle of 20° to the horizontal plane.

6. When you have entirely finished with the above questions and your instruments, give up all your rulers, compasses, &c., &c., to the duftry, and draw by free hand only the ornament in copy to be then supplied to you, half size.

APPRENTICE DEPARTMENT.

FINAL EXAMINATION, 1891.

4th year.

ARITHMETIC AND ALGEBRA.

1. Simplify $\frac{7}{11}$ of $\frac{\frac{19}{21}-\frac{9}{49}-\frac{1}{27}}{\frac{1}{3}+\frac{1}{14}-\frac{1}{9}}$ of $(3\frac{2}{5}+\frac{1}{2}-2\frac{1}{10})$.

2. (*a*) Divide ·15089 by ·0000125.

   (*b*) Add together $3\dot{3}15$, $5\cdot0\dot{1}8$, $3\cdot2\dot{2}\dot{1}$, $4\cdot2\dot{7}\dot{8}$.

   (*c*) Express $\frac{1}{17}$ of £1. 0*s*. $2\frac{1}{4}$*d*. + ·875 of 1*s*. 8*d*. as the decimal of 2*s*. 8*d*.

3. What must be the selling price of an article per ounce for which the seller gave 4*s*. 6*d*. a lb. and which he sells at a profit of $8\frac{1}{3}$ per cent.

4. The discount on a debt of £336-2-0 is found, reckoning interest at 4 per cent., to be £56-0-4; when will the debt be due?

5. (*a*) How much must a man invest in a 4 per cent stock at 103 so that he may have an annual income of £300.

   (*b*) A man has £2,740 stock in the new $2\frac{1}{2}$ per cent.; when they are at $90\frac{1}{8}$ he sells, and invests the proceeds in the 3 per cent. consols at $£102\frac{3}{8}$; find the change in his income, brokerage being $\frac{1}{8}$ per cent.

6. (*a*) Simplify $\frac{1}{(a-b)\ (a-c)}+\frac{1}{(b-c)\ (b-a)}+\frac{1}{(c-a)\ (c-b)}$

   (*b*) Resolve into factors $x^4-x^2-9-2a^2x^2+a^4+6x$.

   (*c*) Extract the square root of—

$$4x^4+32x^2+96+\frac{64}{x^4}+\frac{128}{x^2}.$$

7. Solve the following equations:—

   (*a*) $\frac{x+4}{3}-\frac{x-4}{5}=2+\frac{3x-1}{15}-\frac{1}{4}(x-3)$.

   (*b*) $\sqrt{x+5}+\sqrt{x-4}=\sqrt{4x+1}$

   (*c*)
$$\left.\begin{aligned}\frac{x+y}{2}&=32\\ 2x+z&=12\\ y-x&=2\end{aligned}\right\}$$

8. (*a*) Simplify $4\sqrt{63}+5\sqrt{7}-8\sqrt{28}$.

(*b*) If $\frac{p}{b-c}=\frac{q}{c-a}=\frac{r}{a-b}$, shew that $p+q+r=0$.

(*c*) The area of a circle varies as the square of its diameter; prove that the area of a circle whose diameter is $2\frac{1}{2}$ inches is equal to the sum of the areas of two circles whose diameters are $1\frac{1}{2}$ and 2 inches respectively.

9. Insert 20 arithmetic means between 4 and 67.

10. Sum the series—

(*a*) —3, 1, 5, to 17 terms.

(*b*) $\frac{1}{2}, \frac{1}{3}, \frac{2}{5}$, to 7 terms.

(*c*) ·9, ·03, ·001, to infinity.

11. (*a*) Write down and simplify the 7th term of

$$\left(1-\frac{1}{x}\right)^{10}$$

(*b*) Expand to four terms

$$(1-x^2)^{-\frac{1}{2}}$$

Geometry and Mensuration.

1. Define rectilineal figure, quadrilateral, segment of a circle, angle in the segment, compound ratio. State the 8th axiom and name one proposition where it is made use of.

2. (*a*) At a given point in a given straight line to make a rectilineal angle equal to a given rectilineal angle.

(*b*) Construct a triangle, being given the base, one of the angles at the base, and the difference of the sides.

3. The diameter is the greatest straight line in the circle, and of all the others, that which is nearer to the centre is always greater than one more remote, and the greater is nearer to the centre than the less.

4. Through a given point without a given circle, to draw a chord equal to a given straight line.

5. In a given circle to inscribe a triangle equiangular to a given triangle.

6. A trapezoid the parallel sides of which are in the ratio of 3 : 4 is to be cut from a rectangular board 12 feet long and 2 feet wide; find the lengths of the parallel sides that the trapezoid may be $\frac{1}{3}$ of the board

7. The area of the surface of a frustum of a square pyramid is 100 square feet, the perimeter of the base is 13 feet 4 inches, and the slant height is 10 feet; find the area of the top.

8. An embankment is made upon a slope of 1 in 10, the top of the embankment is horizontal, and its section everywhere a trapezoid: its greatest height above the slope is 57 feet and breadth of the top

26 feet, and the slopes of the sides 1 in 1; find the number of cubic yards, in a length of 150 yards, of the embankment.

9. A square-threaded screw, with double thread, is formed upon a cylinder 3 inches in diameter; the thread projects from the cylinder $\frac{1}{10}$ of an inch, and the screw rises 3 inches in four turns; find the volume, if the screw be 9 inches in length.

10. The height of a segment of a sphere is 5 feet and the diameter is 15 feet; find the volume.

Trigonometry and Hydrostatics.

1. Find from definition, to three places of decimals, the sines of 30°, 135°, 240°.

2. Prove that $\cos(A-B) = \cos A \cos B + \sin A \sin B$, and that $\sin A + \sin B = 2 \sin\frac{A+B}{2} \cos\frac{A-B}{2}$.

3. If A, B, C are the three angles of a triangle, prove that $\sin 2A + \sin 2B + \sin 2C = 4 \sin A . \sin B . \sin C$.

4. The three sides of a triangle are 3″·25, 5″·67, 4″·38. Find the three angles and the area of the triangle.

5. A is a point to the south and B to the north of an obstacle. At A an angle of 53°·45′ is measured from the north towards the west, and along the line so found a distance $AC = 438$ yards in measure. From CB is visible and CB makes an angle of 75°·18′ with CA. The length CB is found to be 339 yards. How far is B from A?

6. Define pressure *at* a point. Describe an apparatus intended to shew that pressure applied at the surface of a liquid is propagated equally in all directions through the liquid.

7. What do you mean by specific gravity. A mixture is made of 2lbs. of a liquid whose specific gravity is 1·3, 3lbs. of a liquid of specific gravity ·76, and 4lbs. of a liquid of specific gravity ·79. Find the specific gravity of a body which will float in the mixture with half its volume immersed.

8. Define "total pressure" on a surface. Prove that the total pressure on a surface in a liquid is equal to the weight of a column of liquid whose base is equal to the area, and whose height is equal to the depth of the centre of gravity of the surface.

9. The gates of a dock are 30 feet deep and 40 feet wide, and the water against them is 25 feet deep. Find the magnitude and point of action of the resultant pressure on the gates. If the water remained of the same depth, but the extent of water in the docks behind the gates became larger, would the pressure on the gates increase?

10. A cone of iron (specific gravity 7·8) 6″ high and 4″ base diameter is hung in water by a string. Find in pounds weight the tension of the string. If $\frac{1}{2}$lb. of cork (specific gravity ·24) is fastened to the cone, what is now the tension of the string?

STATICS AND DYNAMICS.

1 State the propositions called the parallellogram of forces and the triangle of forces. ABC is a triangle. Forces acting at a point are represented in magnitude and direction (1) by AB, BC, CA, (2) by AB, BC, AC, (3) by AB, CB, CA. Find the resultant in the three cases.

2. Define the moment of a force about a given point and about a given line. Prove that the moment of the resultant of any number of parallel forces about a point is equal to the sum of the moments of the components about the point.

3. Find the centre of gravity of three equal masses, one at each corner of a triangle. ABC is a triangular board, E is the middle point of AB, and F the middle point of AC. On $EFBC$ is fastened a board of the same thickness as ABC, but of twice as heavy material. Find the centre of gravity of the whole.

4. Shew that in the first system of pulleys, neglecting friction, the work done by the power is equal to the work done on the weight, when the latter is lifted through a given height.

5. Show how to determine the graduations in a common steel-yard.

6 Define velocity and acceleration. Find in feet per second the velocity due to the daily motion of a point on the earth's equator; given that the radius of the earth is 4,000 miles. Has such a point any acceleration?

7. A body moves from rest under the action of a force constant in magnitude and direction; find how far it will move in a given time.

8. Describe the principle of Atwood's machine.

At one end of the string there is 8 oz. and at the other 6 oz. How fast will the heavier weight be falling at the end of 3 seconds from starting?

9. Prove that the velocity acquired by a body in falling down a smooth inclined plane is the same as would be acquired in falling vertically through the height of the plane, and that the work done is the same whether the body is pulled up the plane or lifted vertically through the height of the plane.

10. Distinguish between work and horse-power.

Find the horse-power of an engine that will pull a train of 50 tons up an incline of 1 in 200 at the rate of 20 miles an hour, the resistance from friction being 10lbs. per ton.

ENGINEERING AND APPLIED MECHANICS.

1. What maximum pressure per square foot on bed of foundations is allowable in ordinary soil round Calcutta? What depth of concrete would you place under the walls of a two-storied building in the neighbourhood of the College?

2. Explain what is meant by forge pig and foundry pig, and how you would distinguish between them.

3. What is the difference between a chalk lime and a ghooting lime? Which is the best for internal plastering, and why?

4. Write a specification for an ordinary terraced roof supported on teak beams and burgahs. Give the approximate weight per square foot of such roofing, and the dimensions, without calculations, of the beams 20 feet long and 3 feet apart.

5. An arch is a quadrant of a circle of 30 feet internal radius, The depth of the arch at the crown is 2 feet. If the weight of the material is 120lbs. per cubic foot, what is the horizontal thrust?

6. The length of a beam supported at its ends is 20 feet. Find the amount of a uniformly distributed load that will produce a shearing force of 10 tons at 2 feet from one end.

7. A rolled wrought-iron joist of I section is 8 inches deep, flanges 5 inches broad, and thickness of web and flanges $\frac{3}{8}''$. If it rests on supports 20 feet apart, what uniformly distributed load should be placed on it so as to produce a longitudinal stress of 4 tons per square inch in the flanges at the central section, neglecting the weight of the joist itself?

8. A wind pressure of 8,000lbs. acts at right angles to one rafter of a king-post truss. Span of roof 30 feet: rise of rafters 36°: rafters bisected by struts. Find graphically the stresses in the various bars of the roof. Scale for loads to be 2,000 lbs. = 1 inch.

9. What load will a wooden pillar 12 feet long and 6 inches square in section support if the safe coefficient for compression is 1,200lbs., and c in Gordon's formula is $\frac{1}{250}$? The ends of the pillar are fixed.

10. A wrought-iron plate girder of 80 feet span carries a moving load of one ton per foot run. Find the maximum shearing force, and bending moment, at sections 10, 20, 30, and 40, feet from one end.

If the effective depth of the girder is 7 feet, what area of metal is required for the compression flange at the centre if the limiting intensity of stress allowed is 4 tons per square inch.

Surveying.

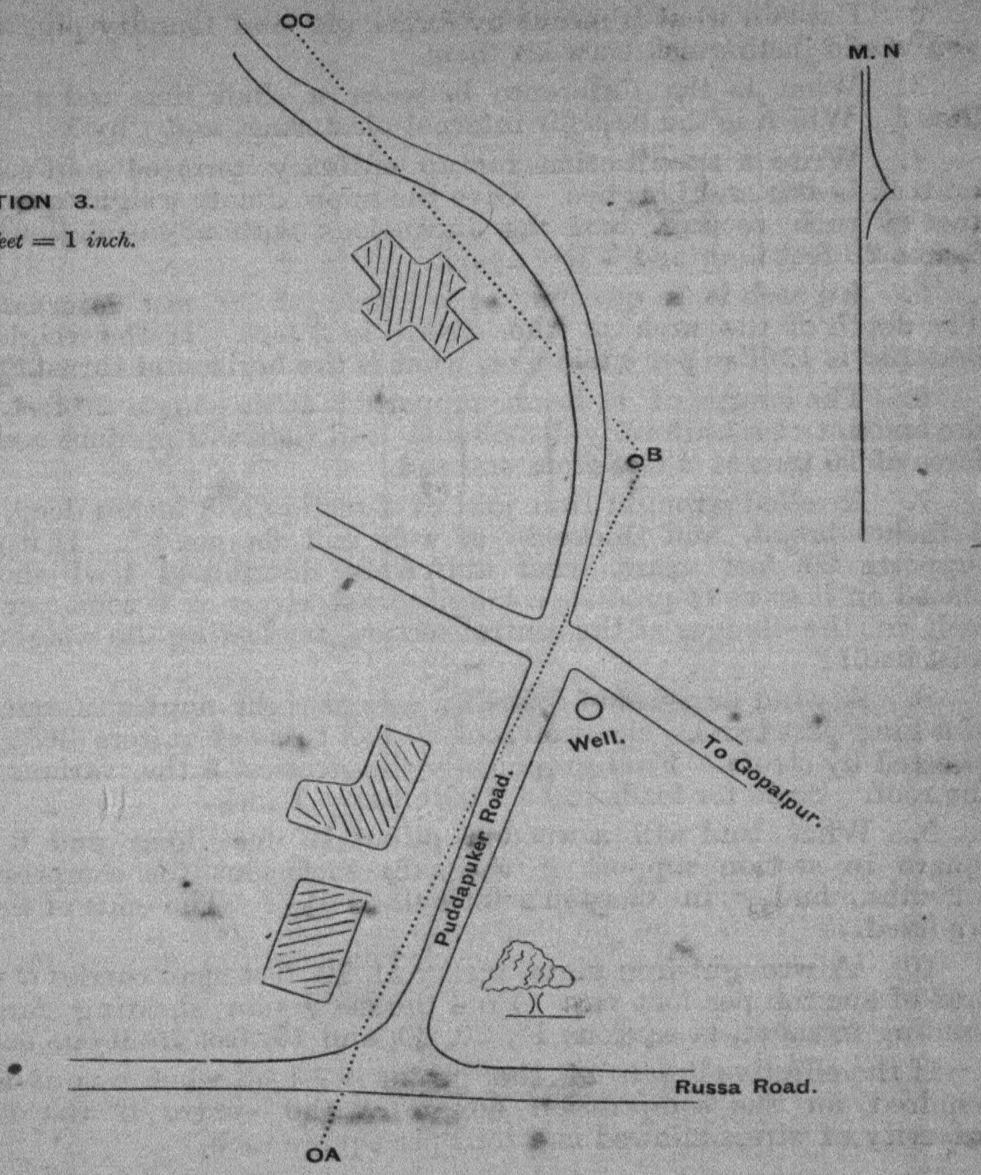
1. Determine the scale, expressed as so many inches to the mile, to which a map is drawn on which 10 square inches represent an area of 64 acres.

2. A survey is made and plotted, and after the area has been calculated as 1,000 acres, it was discovered that the Gunter's chain used in the survey was just one-fourth of a link too short; find the correct area of the survey and the true length of a line which was measured to be 1.000 feet.

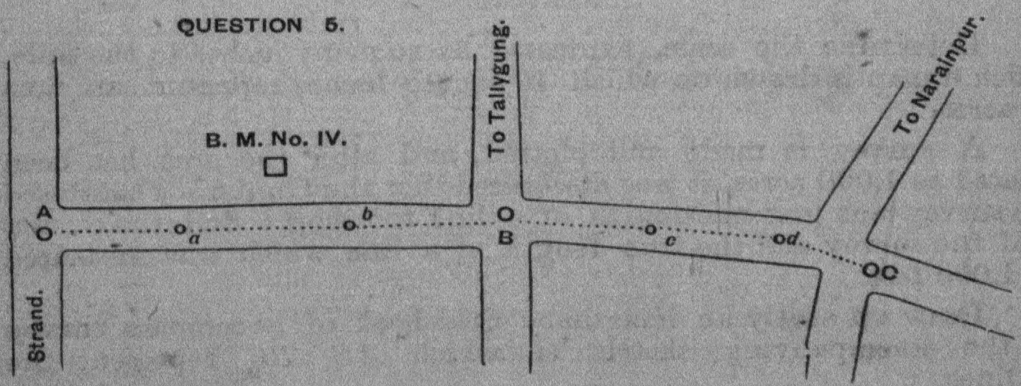
3. Draw up neatly an imaginary field-book of a compass survey from the accompanying sketch, on which AB, BC represent the chain lines.

QUESTION 3.

Scale 150 *feet* = 1 *inch.*



QUESTION 5.



4. Reduce the accompanying page of a level book, and check your work arithmetically :—

Rise.	B. sight.	Int. sight.	F. sight.	Fall.	R level.	Distance.	Remarks.
	5·23	...	...	...	...	0	(A) on peg, centre of Strand Road.
		6·19	...	...	...	100	
		6 25	...	...	...	230	
		7·18	...	...	...	300	(*a*) on top of peg.
		7·79	...	...	...	450	
	4 57	...	4·98	...	20 25	...	On B. M. No. IV.
		7·65	..	...	...	600	(*b*) on top of peg.
		6·89	...	...	...	750	
	5·68	...	5·57	...	.	900	(B) peg, middle of road to Tallyganj.
		4·99	...	...	...	1,050	
	5·21	...	4·15	...	...	1,200	(*c*) top of peg.
		5·76	...	...	...	1,350	
		5 29	...	...	...	1,500	(*d*) top of peg.
			6 74	...	...	1,600	(C) centre of road to Narainpur.

5. *A*, *B*, *C* are points on the surfaces of three existing roads; it is proposed to connect them by a cross road as shown in plan; find the height of embankment or the depth of excavation at the points *a*, *b*, *c*, *d*, so that the surface of the proposed road shall have uniform slopes from *A* to *B* and from *B* to *C*; the levels taken for the purpose are given in question 4.

6. The horizontal wire of a level in perfect adjustment cuts two points *A* and *B*, distant, respectively, half a mile and one-fourth of a mile from the instrument; find the true relative difference of level between the points.

7. (*a*) State the conditions that must be fulfilled in Gale's traverse system, when the traverse makes a complete circuit.
(*b*) Explain how an angle is repeated with the theodolite.

8. Two straight portions of a railway which meet at an angle of 144° 30″ are to be connected by a 2° curve; calculate length of curve, tangent length, and secant length. Nat. tan. 17°42′ = ·3191407
Nat. sec. 17°42′ = 1·0496908

or, explain what is meant by (*a*) the meridian of a place,
(*b*) the variation of the compass,
and (*c*) the latitude of a place.

(*d*) How would you determine the meridian of a place by observation on the sun or star with a theodolite?

Mechanism and Steam-Engine.

1. Sketch a D slide valve, and explain the action of outside and inside lap on the valve.

2. What points connected with the working of steam-engines are revealed by indicator diagrams?

3. Sketch and describe the action of a Bourdon's pressure gauge.

4. How many square feet of teak planking will a 10HP engine saw in three hours, if 25,000 units of work are required for each square foot?

5. The diameter of each of the two pistons of a portable engine is 9 inches; the length of stroke is 2 feet; the mean effective pressure of the steam is 30lbs. per square inch; find the horse-power if the engine works at one stroke a second.

6. Describe a screw-cutting lathe.

7. A wheel of 72 teeth makes 30 revolutions per minute, and gears with one of 180 teeth fixed to the axis of a 5 feet diameter drum. Through how many feet per minute will the drum lift a load?

8. Sketch a hand drilling machine. If the bevil wheel attached to the handle has 42 teeth, and the one attached to the nut working the screw which gives motion to the drill has 28 teeth, and if the screw has ten threads to an inch, how may revolutions would be required to bore through half an inch of metal?

9. In Watts' parallel motion show how to find the point in the link which most nearly moves in a straight line.

10. The diameter of a pitch circle is 4 feet; number of teeth 120; find the pitch of the teeth, and draw two wheels of this diameter in gear, showing 3 teeth in each, full size.

Estimating.

Estimate in the following order: —

1. Arch masonry.
2. Plain masonry.
3. Plaster on exposed faces.
4. Draw out abstract of cost.

Drawing.

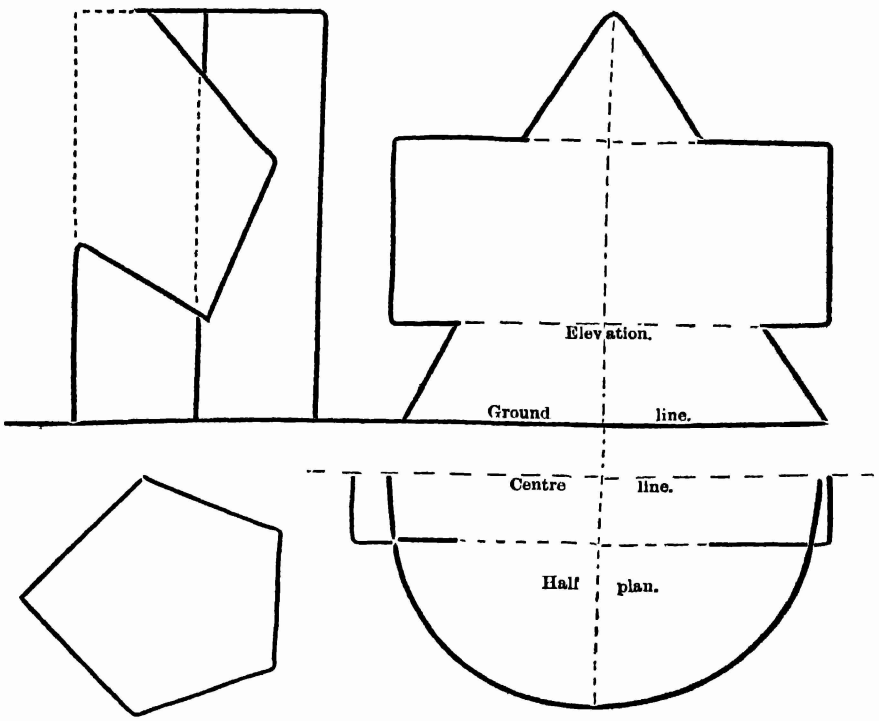
1. *Scales.*—Draw the following:—(1) $\frac{1}{30}$th full size, (2) $3\frac{1}{4}$ feet to 1 inch, (3) $1\frac{1}{4}$ inch decimal diagonal, and (4) a scale of chords.

2. Draw side elevation and plan of prism in margin, showing section.

3. Develope surfaces of prism and section.

4. Draw a projection of prism and section on the inclined plane. The base to be at 20° to the horizontal plane and one edge of pentagon to rest on the horizontal and make 15° with the vertical plane.

5. Draw the curve of penetration on elevation and plan in margin.



Chemistry.

1. How would you ascertain the composition of water by an accurate synthetical experiment?

2. How is concentrated nitric acid prepared in the laboratory?

3. What is the most convenient way of preparing an aqueous solution of ammonia on a small scale?

4. Write down the formulæ of all the oxides of carbon, sulphur, iron, lead, manganese.

5. How do sulphurous acid and chlorine act as bleaching agents?

6. Give a brief sketch of one of the processes of reducing galena to metallic lead.

7. What is the percentage composition of silver nitrate and calcium sulphate?

8. A substance has the following percentage composition; what is its molecular formula?

K =	28·16
Cl =	25·63
O =	46·21
	100 00

Physics.

1. What methods have been used to determine the coefficients of expansion of liquids?

2. What is meant by the following terms:—apparent and real expansion, evaporation, ebullition, regelation, sublimation?

3. Give a general statement of the effects which heat produces in different bodies.

4. Define heat of liquefaction, heat of evaporation, mechanical equivalent of heat. Why is the term latent heat objectionable? What is the numerical value of the heat of liquefaction and evaporation of water and the thermal equivalent of work?

5. What is meant by the following statements?

(*a*) The specific heat of copper is 0·0942.

(*b*) The atomic heat of silver is 6·15.

(*c*) The relative conductivities of silver and iron are 100 and 10·1 respectively.

6. How would you construct a Leyden jar; what is its action?

7. Given a feeble magnet and a number of thin bars of steel, how would you construct a strong magnet?

8. Describe and explain the action of Grove's cell.

9. State the laws which regulate the action of one current on another.

APPRENTICE DEPARTMENT.

	Name.	Year.	Present employment.
	Ashini Kumar Mookerjee ...	1883	Public Works Department, Bengal, Railway Branch, Darjeeling.
	A. E. DeSilva	1883	
	W. Traise	1883	Public Works Department, 2nd Calcutta Division.
	W. M. Halloran	1883	Public Works Department, Chittagong Hill Tracts.
5	F. Alone	1883	Overseer, District Board, Benares.
	H. Gilbert	1883	Public Works Department, Assam.
	J. R Moorhouse ...	1883	Foreman, North-Western Railway Workshops, Lahore.
	E. B. Walker	1883	Calcutta Municipality.
	H. Bryning	1885	Overseer, B. S. Railway, Swebo.
10	C. Perierra	1885	Calcutta Municipality.
	T. Rolston	1885	Public Works Department, Burma.
	Shoshi Bhusan Ghosh ...	1885	District Board, Chapra.
	Shaik Sudder Ali ...	1886	Burma Public Works Department.
	G. Branscombe	1886	Overseer, Arracan Division, Burma.
15	Bani Kanta Biswas ...	1886	Faridpur Municipality.
	Sarat Chundra Roy ...	1886	Chittagong Public Works Department.
	Jogesh Chundra Bose ...	1886	Calcutta Public Works Department.
	Rajoni Nath Bál	1886	District Board, Mymensingh.
	Basanta Kumar Ghosh ...	1887	Midnapore Technical School.
20	Raghupati Banerjee ...	1887	District Board, Purnea.
	A. Cuerden	1887	Overseer, North-Western Provinces.
	Harilal Sanyel	1887	Faridpur District Board.
	O. A. Browne	1887	Public Works Department, Jubbulpur.
	J. C. Damzen	1887	East Indian Railway, Allahabad.
25	W. Gomes	1887	Overseer, Public Works Department, Mandalay.
	Tranoda Churn Mittra ...	1887	Calcutta Public Works Department.
	J. H. Roy	1887	Indian General Steam Navigation Company's Steam-ship *Lucknow*.
	Upendra Nath Ganguli ...	1887	Public Works Department, Calcutta.
	Tuniram Borua	1887	Assam.
30	Bhuban Chundra Banerjee ...	1888	Out of employment.
	Nogendra Nath Chakravarti ...	1888	Public Works Department, Bengal, Railways.
	Jodunath Biswas	1888	Sub-Overseer, Public Works Department, Darjeeling.
	E. Martin	1888	Eastern Bengal State Railway, Lungi, Budge-Budge.

	Name.	Year.	Present employment
	Heralal Pal	1888	Surveyor-General's Office, Calcutta.
35	Keshub Lal Chatterjee	1888	Kidderpore Dock.
	R. Rogers	1888	Foreman, Lahore Workshop.
	C. Hodge	1888	Overseer, Midnapore Municipality.
	Batta Krishna Singh	1888	Calcutta Public Works Department.
	Harish Chandra Pal	1888	Jalpaiguri Public Works Department.
40	Ashutose Bhattacharjee ...	1888	Chittagong Public Works Department.
	A. E Linton	1888	East Indian Railway.
	G. Morris	1888	Public Works Department, Cheera Punji.
	A. Bonnar	1888	
	Surendronath Mittra	1888	Deceased.
45	Sarat Chundra Bose	1889	Burn & Co., Howrah.
	P. Westerling	1889	Deceased.
	C. Hottinger	1889	Temporary Upper Subordinate, Public Works Department, Mergui.
	Kartick Chunder Bose	1889	Private works, Calcutta.
	H. Michael	1889	Mackintosh, Burn & Co.
50	Degumber Hui	1889	District Board, Muzaffarpur.
	Rohini Kumar Bhattacharjee ...	1889	Muzaffarpur Railway.
	G. M. Gregory	1889	Penang.
	Jogendra Nath Ganguli ...	1890	Survey Teacher, Patna College.
	Nripendra Nath Bose	1890	Public Works Department Sub-Overseer, Ranchi.
55	Srimanta Ch. Chaudhri	1890	
	Brojendra Kumar Dass	1890	Overseer, Karremgunge.
	D. W. D'Cruze	1890	
	C. J. Homer	1890	
	G. F. Hottinger	1890	Temporary Upper Subordinate, Public Works Department, Moulmein.
60	J. S. O'Connell	1890	Overseer, Central Provinces.
	Sreekanta Roy	1890	Ditto, Local Board, Pirojpur, Barisál.
	Romesh Chunder Dutt	1890	Head Master, Technical Institution, Barisál.
	Modhu Sudan Adhicary ..	1890	Sub Overseer, Public Works Department, Bengal.
	Surjee Kumar Chatterjee ...	1890	
65	Rojoni Kanta Deb	1890	Kashipore Municipality Surveyor.
	Upendra Nath Hazra	1891	
	Panch Cowri Mukerjee	1891	
	Satis Chundra Mittra	1891	
	J. G. Dolmar	1891	
70	Gyanendra Nath Banerjee ...	1891	Private Workshop, Sibpur.
	Kristo Dhone Ghose	1891	Overseer, Public Works Department, Arran.
	R. D. Clark	1891	
	Haran Chundra Biswas	1891	
	Hari Narayan Sarkar	1891	
75	Chandra Kanta Chatterjee ...	1891	

N B.—Any inaccuracies in above list should be brought to the notice of the Principal. Passed apprentices out of employ should register their names and addresses in the Principal's office. It is particularly requested that, on any apprentice getting an appointment or changing his appointment, the information be forwarded to the Principal for incorporation in the College Calendar.

MISCELLANEOUS CERTIFICATE HOLDERS.

Certificates granted under Section I, paragraph 13, *Chapter II, Public Works Code of* 1878.

ASSISTANT ENGINEERS.

NAME.	Year.	Remarks.
Lalit Mohun Basack	1881	Also passed L. C. E.
T. B. Byers	1881	Ditto.
P. W. Byers	1881	Ditto.
Kapileswar Bhattacharjee	1881	
Sita Prosono Rai	1882	Also passed L. C. E.
Mritunjoy Bhattacharjee	1882	

Certificates granted under Section II, paragraph 51, *Chapter II, Public Works Code of* 1878.

SUB-ENGINEER.

Ram Das Bhattacharjee	1884	

Certificates granted under Section II, paragraph 31, *Chapter II, Public Works Code of* 1878.

OVERSEERS.

Amin Uddin	1880	
Abinas Chunder Roy	1880	Also passed L. C. E.
Kapileswar Bhattacharjee	1880	Passed for Assistant Engineer.
Nemi Churn Ghose	1880	
Gopal Chunder Bhattacharjee ...	1880	
Russick Lal Mukerjee	1880	
Lolit Mohun Basak	1880	Passed L. C. E.
Pran Krishna Sen	1880	Ditto.
Sita Prosonno Rai	1880	Ditto.
Bishnuram Chakraverti	1880	
Satya Churn Banerjee	1881	Passed L. C. E.
Kali Krishna Mozoomdar	1881	
Apurva Krishna Sen	1881	
Kali Gopal Rudra	1881	
C. E. Lefeuvre	1882	
Annoda Prosad Pal	1882	
Shama Churn Ganguli	1882	
Akhil Chunder Marik	1883	Passed L. C. E.
Lal Chand Mittra	1883	
Banku Behari Mukerjee	...	Passed L. C. E.

Certificates granted under Section I, paragraph 8, *Chapter II, Public Works Code of* 1870.

SUB-OVERSEERS.

NAME.	Year.	Remarks.
Sudhamay Dutt	1880	
Monmotho Nath Mukerjee ...	1880	
Haripodo Chatterjee	1880	
Sivadas Bhattacharjee	1881	
Lal Chand Mittra	1881	Also passed as Overseer.
Sarat Chunder Roy	...	
Annoda Prosad Sarkar	1881	Passed L. C. E.
Tarini Churn Roy	1881	
Mohim Chunder Rudra	1882	
Banwari Lal Banerjee	1883	
Chandra Kanta Bose	1890	

Certificates granted under Director of Public Instruction's No. 5677, *dated* 23*rd July* 1884.

THIRD GRADE OVERSEERS.

Kuloda Nanda Mukerjee ...	1885	
Preo Nath Roy	1886	
Jadu Nath Mittra	1886	
Surendra Nath Sen	1886	
Troylocko Nath Dutt	1888	
Gopal Chundra Roy	1888	
Nebaran Chundra Chatterjee ...	1888	
Surja Kumar Das	1889	
Makhan Lal Sarkar	1890	
Chanchal Chundra Banerjee ...	1890	
Jogendra Lal Pal	1890	
Notobar Ghosal	1891	
Kaliprosonno Sen	1891	
J. Morrison	1891	

Certificates granted under Director of Public Instruction's No. 4221, *dated* 15*th May* 1884.

SUB-OVERSEERS.

Raj Kumar Ganguli	1884	
Jadub Chupder Chatterjee ...	1885	
Bepin Behari Gupta	1885	
Sitanath Bhuttacharjee ...	1885	
Nikunja Behari Bose	1886	
Bejoy Krishna Mukerjee ...	1886	

Certificates granted under Director of Public Instruction's No. 4221, *dated* 15*th May* 1884—contd.

SUB-OVEESEERS—*contd.*

NAME.	Year.	Remarks.
Nritya Gopal Bhuttacharjee ...	1886	
Raj Krishna Mandal	1887	
Heera Lal Santra	1887	
Chanchal Chundra Banerjee ..	1887	Also passed as 3rd grade Overseer
Kaliprosonno Sen	1887	Dittto ditto.
Baroda Kanta Thakoor	1888	
Sidheswar Mozoomdar	1888	
Gopal Chundra Lahiri	1888	
Upenda Nath Sen Gupta ...	1888	
Mohendra Nath Gossamy ...	1888	
Kamini Kanta Bhuttacharjee ...	1888	
Upendra Nath Chandra ...	1888	
Annoda Churn Ghose	1888	
Protap Chunder Ghose	1889	
Dakshinaranjan Muchaddi ...	1889	
Tarak Nath Chowdhry	1891	
Soshibhusan Bhuttacharjee ...	1891	
Pulin Behari Ghose	1891	
Brindaban Chundra Mukerjee ...	1891	
Pulin Behary Shaha	1891	
Jaggut Bundhoo Gupta	1891	
Brojendra Nath Chatterjee ...	1891	
Saroda Prosad De	1891	
Surendra Nath Banerjee ...	1891	
Ashutosh Chatterjee	1891	
Nogendranath Chatterjee ...	1891	
Lalbehary Roy	1891	
Debendra Nath Sen Gupta ...	1891	
Jogendra Nath Ghose	1891	
Surjya Kumar Roy	1891	
C. Raynard	1891	
Panchanun Ganguli	1891	
Purna Chandra Dutt	1891	
Dakshineswar Chatterjee ...	1891	

ACCOUNTS.

Examination qualifying for admission to the Subordinate Accounts Branch for 4th Grade, P. W. D.

SUBJECTS FOR EXAMINATION.

	Full marks.	Minimum pass marks.
Writing (neatness, clearness and rapidity) ...	100	50
Dictation (spelling, punctuation, &c.) ...	100	50
Arithmetic (whole course)	240	160
Mensuration (*a*) (whole book)	60	30
Book-keeping (*b*) Mercantile	100	50
Total ...	600	400

Minimum required in all papers collectively.

(*a*) Todhunter's Mensuration for beginners.
(*b*) " Book-keeping " by Bull and Hamilton.
" Book-keeping " by double and single entry by W. Inglis (Chamber's Educational Course).

The marks gained by candidates who fail will not be published.

1. The examination is held annually at the Civil Engineering College, Sibpur, on the 1st Monday in June. The examination will be conducted either at the College or by an Examiner, Public Works Accounts (including Railway and Telegraph) in Bengal, Assam, and Burma only.

Candidates will not be examined in any of the Calcutta offices.

2. Candidates not in Government employ who wish to be examined at the College must forward their applications direct to the Principal; those employed in Government offices through the head of their office, who will forward the application to the Principal.

All applications must reach the Principal 30 days before the date of examination.

3. The candidate should apply to an Examiner of Public Works Accounts not later than 30 days previous to the date fixed for the examination, and obtain his consent to conduct the examination if examination at the College is not convenient. The application must be forwarded by the candidate, not direct to the Principal, but through the Examiner.

All applications must be accompanied by a fee of Rs. 10 and the following certificates.

Certificates may be submitted in original, or true copies attested by an officer of the Engineer or Accounts Branch, but none will be returned :—

(1) Certificate of good character signed by applicant's immediate official superior, or by the instructor under whom he has been educated, or by some other superior under whom he may have been brought up or employed, or to whom he may be well known. (This certificate must have special reference to the two years immediately preceding the application.)

(2) Certificate that candidate is under 25 years of age (not required if candidate is in permanent Government employ, or an employé under District Boards).

(3) Certificate that the application is in candidate's handwriting.

It will rest with the Principal of the College, on a consideration of these certificates, to decide whether the candidate should be registered for the examination, or whether his application should be rejected.

5. Copies of examination papers are not procurable except those that are issued for examination. These need not be returned.

6 Each examination is complete in itself. A candidate who has failed in an examination, and presents himself for examination on a subsequent occasion, must undergo the full examination, and furnish a fresh fee and certificates.

7. Passed candidates should apply, not to the Principal of the College, nor to the Accountant-General, Public Works Department, but direct to the Examiner of Public Works Accounts in the Province or Railway under whom they may desire to be employed.

8. It must be distinctly understood that the passing of this examination does not give any claim to an appointment, and that in making appointments, preference will be given to qualified persons who are already employed in the Department.

ACCOUNTANTS.

	Names.	Year.	
	4th grade Accountants.		
	Sarada Prosad Bhattacharjee	1880	
	Lalla Nanak Chand ...	1880	
	Shangsor Chander Banerjee ...	1880	
	Gustadji Dhanjishah Kagsadia	1880	
5.	Albert Clifford Owen ...	1880	
	Sarabjee Bamanjee ...	1880	
	Abhoy Charan Roy ...	1880	
	Choony Lall Magan Lall ...	1880	
	Ram Chander Bhote ...	1880	
10.	James D. Rozario... ...	1880	
	T. McCann	1880	
	Uma Prosad Bagchi ...	1880	
	Amrito Lall Bose	1880	
	Notobor Mukerjee ...	1880	
15.	Nondo Lall Bhattacharjee ...	1881	
	Sidheswar Roy	1881	
	W. J. Dunn	1881	
	Mohendro Nath Roy ...	1881	
	Dwarka Nauth Sen ...	1881	
20.	Kedar Nauth Biswas ...	1881	
	David O'Dowda	1881	
	George Augustus Damzen ...	1881	
	Aghore Nauth Dutt ...	1881	
	Nobin Krisna Bhattacharjee ...	1881	
25.	Uma Sankar	1881	Passed under section IV, paragraphs 59 and 60, Chapter II, P. W. D. Code of 1878.
	J. Corrigan	1881	
	Kamikhya Nauth Banerjee ...	1881	
	Moolji Bhagwan Shett ...	1881	
	A. C. C. McLeish ...	1881	
30.	Baidya Nauth Bhattacharjee ...	1881	
	Jogot Chander Mukerjee ...	1881	
	A. Ganguly	1881	
	William Kelly	1881	
	Gour Gopal Dey	1881	
35.	Ranga Nauth Kasi Nauth Fausi	1881	
	Kirti Chander Chatterjee ...	1881	
	Ganoda Prosad Ganguly ...	1881	
	Francis George Harris ...	1881	
	Jules Bell	1881	
40.	Atul Krisna Dutt... ...	1881	
	Behari Lal Chatterjee ..	1881	
	T. Subramoney Aun ...	1881	
	Arthur McLean	1881	
	Keshub Chander Singhi ...	1881	
45.	Dasorothi Banerjee ...	1881	
	Lalla Mulk Roy	1882	
	Amor Nauth Ganguly ...	1882	
	F. W. McGrath	1882	
	Richard Frederick Drame ...	1882	
50.	Lalla Nibu Ram	1882	

	Names.	Year.	
	4th Grade Accountants—*continued.*		
	Pundit Gopi Nauth ...	1882	
	Sree Nauth Mittra ...	1882	
	Keshob Chander Ghose ...	1882	
	C. Narsiah	1882	
55.	P. Varejanabhudu Naidu ...	1882	
	Cheddi Lal	1882	
	Bhowani Charan Boral ...	1882	
	Shashi Bhusan Pal ...	1882	
	William Lemon	1882	
60.	E. L. Richards	1882	
	Daniel Bates	1882	
	Upendro Nath Mittra ...	1882	
	Narayan Chander Roy ...	1882	
	John Green	1882	
65.	W. H. E. Turner	1882	
	Sarat Chander Mitter ...	1882	
	Nezaiudin	1882	
	Autul Behary Das ...	1882	
	Mohini Mohon Bhattacharjee	1882	
70.	Oscar William Malletti ...	1882	
	Rajendro Nauth Mukerjee ...	1882	
	Alexander M. Carson ...	1882	
	John Thobwing	1882	
	Allice Alex Philbert ...	1882	
75.	Sam Joachim	1882	
	Cecil Joachim	1882	
	Vallah Hargovindo Almarram Bhuckhanwalla	1882	Passed under section IV, paragraphs 59 and 60, Chapter II, W. P. D. Code of 1878.
	Shoshi Bhusan Pal ...	1882	
	Nicholas John Jebb ...	1882	
80.	Makhan Lal Roy ...	1882	
	Bireswar Mukerjee ...	1882	
	John Rodda Dunn ...	1882	
	Herbert Butterfield ...	1882	
	Probodh Chander Gupta ...	1882	
85.	Madho Ram	1882	
	Archibald Gregory ...	1882	
	Thomas Michell Shaw ..	1882	
	James Argyle Smith ...	1882	
	Reginald Peyton Dunlop Burbridge.	1883	
90.	Tranada Charan Mittra ...	1883	
	Augustus DeSouza ...	1883	
	Reginald Medlycott ...	1883	
	Nathu Jamnadas	1883	
	Sarat Chander Chowdhury ...	1883	
95.	Nobin Chander Sen ...	1883	
	Annada Prosad Dutt ...	1883	
	Richard A. Creenumey ...	1883	
	Mahomed Jalaluddin ..	1883	
	Bhogobote Charan Mukerjee...	1883	
100.	Alexander Fernie ...	1883	
	Pundit Modon Mohon ...	1883	
	Abdul Goni	1883	

	Names.	Year.	
	4TH GRADE ACCOUNTANTS—*continued.*		
	Shoshi Kumar Mozoomdar ...	1883	
	Kedar Nath De	1883	
105.	Hari Nauth Singha ...	1883	
	Thakur Das	1883	
	Le. C. Rostan	1883	
	Kailaspotty Banerjee ...	1883	
	Moti Lal Mukerjee ...	1883	
110.	Debi Singh	1883	
	Adhor Nauth Banerjee ...	1883	
	Hira Lal Roy Chowdhury ...	1883	
	James Thomas Evans ...	1883	
	J. Geo. B. Armour ...	1883	
115.	E. L. Mendes	1883	
	Damodor Dutt	1883	
	Karam Chand	1883	
	Earnest H. D'Cruz ...	1883	
	Govindo Ram	1883	
120.	Ram Chander Chaturwedi ...	1883	
	Chirag Deen	1883	
	Tarapodo Ghose	1883	
	James Younan	1883	
	Chatturbhooj Dobey ...	1883	
125.	Parjaram Naratam Das Adhyaree	1883	
	Hari Charan Dutt	1883	
	Ram Chander Banerjee ...	1883	Passed under section IV, paragraphs 59 and 60, Chapter II, P. W. D. Code of 1878.
	Pundit Niranjan Nauth ...	1883	
	Mul Raj Khoola	1883	
130.	Pundit Ishar Das	1883	
	Bapalal Kikabhai	1883	
	Moola Ram	1883	
	Kirtibas Bhattacharjee ...	1883	
	Joges Chunder Chatterjee ...	1883	
185.	Louis R. St. Romaine ...	1883	
	Makando Ram	1883	
	Mohon Lal	1883	
	Monohor Lal	1883	
	Hem Chunder Ghose ...	1883	
140	A. Belletty	1883	
	Sham Narayan	1883	
	Jamsetjee Eduljee ...	1883	
	Ishar Dass	1883	
	Gunda Singh Moonshi ...	1883	
145.	Tulsi Ram	1883	
	Charles Raymond Martin ...	1883	
	Okhoy Kumar Roy ...	1883	
	Ganga Shohay	1883	
	R. Krishna Sawmey Naicker ...	1883	
150.	Sohan Lall	1884	
	Nripendro Nath Roy ...	1884	
	Jerome Andrew	1884	
	R. Dowling	1884	
	Ram Narain Banerjee ...	1884	
155.	Karim Baksh	1884	

	Names.	Year.	
	4th grade Accountants—*continued.*		
	Charles Lodrick	1884	
	Ahmed Din	1884	
	Edmond D'Rozario ...	1884	
	Troylukhyo Nath De ...	1884	
160.	Novin Chander Bhattacharjee	1884	
	Durga Prosuda	1884	
	Deepa Shah	1884	
	H. C. V. Sage	1884	
	Henry Walter Fegudo ...	1884	
165.	C. Muirhead	1884	
	Ananto Ram	1884	
	C. S. Murphy	1884	
	Manomed Abdoollah ...	1884	Passed under section IV, paragraphs 59 and 60, Chapter II, P. W. D. Code of 1878.
	Tarapodo Ghose	1884	
170.	Balkrisna Trinbock ...	1884	
	Dabendro Nauth Roy ...	1884	
	Ganga Ram	1884	
	Kassim Beg	1884	
	Barkat Alli	1884	
175.	Mohendro Nauth Ghose ...	1884	
	W. W. De Lattoyde ...	1884	
	Debi Doyal	1884	
	C. L. Jose	1884	
	Gowri Ditta	1884	
180.	Barada Kanta Chowdhury ...	1884	
	Khetra Mohon Bose ...	1884	
	Troylukyo Nauth Chakerbutty	1884	
	Hakim Din	1884	
	V. E. Nepos	1884	
185.	Frederic Chaplin Nisbet ...	1884	
	Badhwa Mul	1884	
	Hera Nand	1884	
	Shyam Lal	1884	
	Kannyhia Lall	1884	
190.	Lakhpot Roy	1884	
	Bipin Behary Dey ...	1884	
	T. Narain Swamey Pillay ...	1884	
	Madho Lall	1884	
	Edmund Cannon Maylan ...	1885	Passed under section IV, paragraphs 59 and 60, P. W. D. Code, 1878.
195.	Arthur Henry Hammill ...	1885	
	Dinshaw Manickji ...	1885	
	Ram Lal Roy	1885	
	Jugal Kisore Byasack ...	1885	
	Ram Chander Govind Talvalkar	1885	
200.	Gopal Das	1885	
	Chandra Mohon Das ...	1885	
	Dharma Das Mukerjee ...	1885	
	Herambo Nauth Chatterjee ...	1885	
	Bhutto Behary Dhor ...	1885	
205.	Brojo Lal Sanyel	1885	
	Bama Charan Chakerbutty ...	1885	
	Amor Nauth Pandit ...	1885	
	Makhan Lal Ghose ...	1885	

	Names.	Year.	
	4th grade Accountants—*continued.*		
	Bhola Nauth	1885	Passed under section IV, paragraphs 59 and 60, P. W. D. Code, 1878.
210.	Bipin Behary Batavyal ...	1885	
	Rajendro Nauth Banerjee ...	1885	
	Denis O'Hearn	1886	
	G. H. Coleman	1886	
	Poorna Chander Dey ...	1886	Passed under section IV, paragraphs 59 and 60, Chapter II, P. W. D. Code, 1878.
215.	Nil Prosonna Ghose ...	1886	
	Kiran Chander Banerjee ...	1886	
	Rash Behary Addi ...	1886	
	Gerald Leith Godwin ...	1886	
	Bipin Behary Banerjee ...	1886	
220.	Poorna Chander Chatterjee ...	1886	
	R. J. Morton	1886	
	Robert Walsh	1886	
	Bidhu Bhusan Banerjee ...	1886	
	Radha Kanto Roy ...	1886	
225.	Munshi Willoyut Hossain Khan	1886	
	Debendro Nauth Bose ...	1886	
	Ashutose Neogy	1886	
	Robert F. George	1887	Passed under Appendix C, paragraphs 12 and 18 of P. W. D. Code of 1886.
	Jiban Krishna Chander ...	1887	
230.	Hyginus Dommerric ...	1887	
	Gracias	1887	
	Bipin Behary Chandra ...	1887	
	Nil Kanto Chatterjee ...	1887	
	Girish Chander Gupta ...	1887	
235.	Dennis O'Sullivan ...	1887	
	Moti Lall Sen	1887	
	A. D. Rozario	1887	
	Michael Charles Edward Dorris	1887	
	Akhoy Kumar Banerjee ...	1887	
240.	Arthur Joseph George ...	1887	
	A. Rainford	1887	
	Leonard Colthurst ...	1887	
	John S. Riley	1887	
	Haraprosad	1887	
245.	Edward Bertram James ...	1887	
	Radha Charan Banerjee ...	1887	
	Kaliprosonna Banerjee ...	1887	
	Kunjabehary Lal	1887	
	Mohendro Nath Das ...	1887	
250.	Shoshi Bhusan Dutt ...	1887	
	Bacharam Audhicary ...	1887	
	Beniprosad	1887	
	Kalidas Bose	1887	
	Uma Nauth Singh ...	1888	
255.	James William Fillinger ...	1888	
	James H. Cameron ...	1888	
	Ashutosh Bhattacherjee ...	1888	
	William O'Cesar ...	1888	
	E. W. Hall	1888	
260.	George Hamilton	1888	

	Names.	Year.	
	4th grade Accountants *concluded.*		
	Shushil Kumar Bose ...	1888	
	Jogendro Kumar Bhadra ...	1888	
	Walter Harold Hodges ...	1888	
	Mihir Chander Dutt ...	1888	
265.	W. A. Samuel	1888	
	Ashutosh Mookerjee ...	1888	
	A. Cum Sone	1888	
	Abinash Chander Ghosh ...	1888	
	A. Vaughan	1889	
270.	Robert Cresswell Keating ...	1889	
	Nilmoney Bose	1889	
	G. Whyte	1889	
	T. A. Johnson	1889	
	Nirode Chander Mozomdar ..	1889	
275.	Hemadrish Chander Bhattacharjee.	1889	
	Bhabani Charan	1889	
	E. Jewell	1889	
	A. Ben Court	1889	
	Albert Aukim	1890	
280.	Kalipodo Banerjee ...	1890	
	Behary Lall Koleh ...	1890	Passed under Appendix C, paragraphs 12 and 18, P. W. D. Code of 1886.
	Brij Behary Sett	1890	
	Bipin Behary Dutt ...	1890	
	Ujjal Chander Sen ...	1890	
285.	Bata Krisna Ghose ...	1890	
	Nogendro Nath Mittra ...	1890	
	Robert B. Smart	1890	
	Arnold Roberts	1890	
	Stephen Robert Ewing ...	1890	
290.	Gourdas Roy	1890	
	Nando Coomar Ganguli ...	1891	
	R. C. Chelliah	1891	
	Deoki Nandan Sahai ...	1891	
	Uma Churan Gupta ...	1891	
295.	Adya Nath Sarkar ...	1891	
	J. E. Rosario	1891	
	Clifford L. Colthurst ..	1891	
	Hem Chandra Ghose ...	1891	
	Surendra Nath Guha ...	1891	
300.	Haridas Tarafdar ...	1891	
	Haridas Mitra	1891	
	A. S. Heberlet ...	1891	
	Kali Das Mookerjee ...	1891	

CIVIL ENGINEERING COLLEGE, SIBPUR.

ANNUAL REPORT, 1890-91.

ENGINEER DEPARTMENT.

Classes.	Hindus.	Europeans and Eurasians.	Mahomedans.	Burmese.	Total.
1st year	33	4	1	1	39
2nd ,, ...	20	...	...	1	21
3rd ,, ...	8	2	...	...	10
4th ,, ...	13	1	1	1	16
Total ...	74	7	2	3	86

The above table shows the state of the Department on 1st April 1890.

B.E. and L.E examinations.

The University examination for B.E. and L.E. candidates commenced on 11th August. Twelve out of the 16 4th-year students, plus 2 former students, were examined. Out of these 14 candidates, 11 (4 B.E., 7 L.E.), or 78 per cent., were successful, one F. F. Bion passing in the first division. Ten of these ex-students are undergoing one year's practical training with the Public Works Department, and one has accepted an appointment. The two guaranteed appointments for the year fall to F. F. Bion and Mohendro Nath Dutt, and the gold medal for the B.E. who gains highest marks in mathematics was awarded to Khirode Chandra Mookerjee.

F. E. examination.

The University F.E. examination was held on the 5th May and 11 following days. The 10 3rd-year boys, plus 1 previous failed, presented themselves before the Examiners, 10, or 90 per cent., passed the examination, 2 getting into the first division. There are therefore now 11 in the 4th-year class, as one old student rejoined.

Annual examination.

The annual college examinations were held in May. Of the 21 2nd-year boys, 20 were examined, and 12, or 60 per cent., were promoted to the 3rd-year class, one only failing in shop's work.

Twenty-five, or 64 per cent., 1st-year boys were promoted to the 2nd-year class, 3 failing in shops, 8 who failed to gain promotion rejoined; 1 has since retired. There are at present therefore 32 boys in the 2nd-year.

Admission.

Sixty-two boys, who had passed the University Entrance examination, applied for admission in June; 47 of these joined, and 12 who failed to gain promotion

were permitted to rejoin, 13 retired during the year, leaving 46 boys in the 1st-year class at the close of the year under review.

The following table gives the numerical strength of this Department on 31st March 1891:—

Classes.	Hindus.	Europeans and Eurasians.	Burmese.	Total.
1st year	42	4	...	46
2nd „	31	...	1	32
3rd „	11	...	1	12
4th „	9	2	...	11
Total ...	93	6	2	101

against a total of 87 on the 31st March 1890.

APPRENTICE DEPARTMENT.

Classes.	Hindus.	Europeans and Eurasians.	Mahomedans.	Total.
1st year	59	11	1	71
2nd „	34	1	...	35
3rd „	33	2	...	35
4th „	15	1	1	17
Senior	13	3	...	16
Total ...	154	18	2	174

The above table gives the state of this Department on the 1st April 1890.

Final certificates.

Of the 16 senior apprentices, 2 were expelled for very serious misconduct in May, 3 left in June, and 9 in February—all with final certificates. Of the remaining two, one is obliged to attend shops for an additional three months on account of not putting in the proper percentage of attendance, whilst the second, as a punishment for general idleness and short attendance, has been dismissed with a final certificate, minus the qualification clause.

Final examination.

Seventeen 4th-year boys appeared at the final examination in July, all passed. One since retired with an appointment. There are therefore now 16 senior apprentices working in the shops.

Annual examinations

The annual examinations were held in January. There were 35 lads in the 3rd-year class. Two of these were expelled in May, 3 retired during the year, and 1 on

account of short attendance was not qualified. Therefore 29 were examined. Of these, 4 failed in shops, and 7 in both shops and class work. Consequently 18, or 62 per cent, were promoted to the 4th-year class.

Out of 35 boys in the 2nd-year class, 1 was expelled in May, 2 left College, 1 died from cholera, 4 were not qualified owing to short attendance, and 27 presented themselves for examination. Five failed in shops and 1 in class work. Twenty-one or 77 per cent., were promoted, 4 who failed rejoined, making 25 in the 3rd-year class.

In the 1st-year class there were 78 boys, 7 having been admitted in June on the result of the University examination. Of these, 3 were expelled, 6 retired during the year, 3 were sick at the time of examination, and 1, owing to short attendance, was disqualified. Therefore 65 were examined. Ten failed in shops and 9 in both shops and class work, so that 46, or 70 per cent., passed, and 10 who failed to gain promotion to the 3rd-year were permitted to rejoin, thus leaving 55 apprentices in the 2nd-year class at the close of the year.

Admission.

For the admission examination in January, 110 names were registered, 91 boys were examined, and 35 passed, but only 27 joined the Department. In addition 3 who passed the University Entrance examination, 3 who passed the same in English and Mathematics, and 13 Europeans, who passed by Standard VII, were admitted. Eight boys who failed to gain promotion were permitted to rejoin. Thus there were 54 in the 1st-year class at the end of the year.

The table below shows the state of the Department on the 31st March 1891 :—

Classes.	Hindus.	Europeans and Eurasians.	Mahomedans.	Total.
1st year	41	13	...	54
2nd „	45	9	1	55
3rd „	24	1	...	25
4th „	16	2	...	18
Senior	14	1	1	16
Total ...	140	26	2	168

against a total of 174 on the 31st March 1890, a decrease of 6. In addition there are two artizan pupils who are taught altogether in the shops. Consequently the grand total on the College books at the close of the year was 271,* and all these, with the exception of 4, reside upon the College premises.

Grand Total.

* Engineers ..	101
Apprentices ...	168
Artizans ...	2
	271

The 40 reduced feeships granted to natives are all taken up, but amongst the 25 for Europeans and Eurasians, there are 10 vacancies. Five Europeans are admitted free. This list is full.

Certificates.

In accordance with rules 10 and 11 of the Apprentice Department, 3 overseers and 11 sub-overseers' certificates were granted by the Principal to the boys leaving the College before the completion of their apprenticeship. These 14, plus the 13 final certificates previously mentioned, make a total of 27 subordinate engineering certificates issued by the College during the year. In addition certificates were granted to two artizan pupils who completed their time in the shops.

Accountants.

An examination for admission to the 4th grade of Accountants, Public Works Department, was held on the 2nd and 3rd June. Fifty-two names were registered and 51 candidates presented themselves for examination. Twelve were successful, and received the usual certificates.

Changes in staff.

Mr. Bartlett, Teacher of Drawing, proceeded to England on one year's furlough, since commuted to 15 months' sick leave, on the 16th April 1890, and Babu Dwarka Nath Dutt was appointed to act for him, Babu Radha Roman Guha being transferred from Dacca Survey School to take up the latter officer's duties as Teacher, Apprentice Department. Babu Surendra Kumar Bose returned from leave on 1st November 1890 and resumed his duties as Teacher in the Apprentice Department, thus setting free Babu Hari Charan Mookerjee, who was acting temporarily. Mr. Slater, Professor of Engineering, returned from furlough on 18th November 1890, and the services of Mr. Oertel, who was acting for him, were placed at the disposal of the Government of the North-Western Provinces. Mr. Kuchler was transferred to the Patna College on 5th January 1891, and Mr. Macdonell was appointed as Professor of Mathematics in his place.

Mr. Shaw was appointed Head Master of the Apprentice Department and Superintendent of the European Mess, in the room of the late Mr. Gilmore, on the 14th February 1891.

Buildings.

The model room attached to the drawing-hall was commenced during the year, and is now almost completed.

The hospital has not yet been sanctioned. It is much needed.

The bank along the College foreshore remains in an unfinished state, impeding drainage and forming noxious swamps.

Surveying.

Survey work with the 2nd and 3rd year engineer classes commenced in November, in the vicinity of Madhupore Station, East Indian Railway, and continued till the end of January. The 3rd-year students were in camp from 24th November till 14th January. This class laid out a line of railway about five and-a-half miles in length. Having selected the line, its position was laid down by the theodolite, and the curves set out. It was then levelled over, cross sections were taken, and the details of the country passed through were filled in by plane table. The 2nd-year students came into camp on 17th November, and remained till 30th January. They were engaged upon an extensive trigonometrical and traverse survey, the details of which were filled in by plane table; also some time was occupied in levelling, contouring, laying out curves and side widths, and in erecting profiles for embankments on sloping ground. In

addition some astronomical observations were made. The 1st-year engineer class executed a chain and compass survey of the Botanic Gardens, and were taught levelling and ground tracing.

The 1st, 2nd and 3rd-year apprentice classes were instructed in chain, compass and theodolite surveying, and in levelling in the neighbourhood of the College.

Works visited.

Mr. J. S. Slater, Professor of Engineering, visited the undermentioned works with the senior Engineer students during the cold season :—

(1) Kidderpore Docks.
(2) Raniganj Pottery.
(3) Bengal Paper Mills.
(4) Barrakur Iron Works.
(5) Jamalpore Workshops.
(6) Burn & Co 's shops.
(7) Barrackpore Water-works.

Models.

No models were purchased during the year, but by a special arrangement the year's model grant is to be expended in London on a variety of useful models selected from a catalogue by the Principal, and on the spot by Mr Bartlett, Teacher of Drawing.

Visitors.

The Board of Visitors met twice during the year, and transacted the routine business brought before it.

Conduct.

The conduct of students has been fair during the year under review with one peculiar exception, when a very serious breach of discipline occurred as follows:—On the night of the 2nd May some apprentice students went without permission to a wedding in Calcutta. They persuaded an unpopular comrade to accompany them, having previously bribed two disreputable characters to stab this companion. They very nearly carried out their murderous design, as the boy was stabbed in the back and so injured that he was laid up for some weeks. The names of the boys engaged in this disgraceful conspiracy were with great difficulty at length discovered, and as a punishment the six ringleaders were expelled, and the others were heavily fined. In the course of investigating this affair it transpired that there was a combination in the College, called the "Gabiz" club, the members of which were sworn to do the maximum of mischief and the minimum of work. The expelled boys all belonged to this club, of which nothing has since been heard, so that it is hoped that this nest of evil-doers has been altogether rooted out.

Another boy, an apprentice, was expelled for attempting to intimidate and for using offensive language to the College Medical Officer.

Athletics.

During the past year the Athletic Club has been in a prosperous condition. The present subscription of Re. 1-8 a year does not admit of any games being played except cricket and football, but the students have played regularly at these, and the natives are beginning to show a certain amount of proficiency in them. Two Hindu boys are in the College eleven, and a third is twelfth man. During the year the College cricket club

played 6 matches with outside teams, won 2 and lost 4 Seven games with outside football teams were played. The College won 2 and lost 5.

The club ground requires a little money to be spent on it in order that two games of football can be carried on at the same time. At present during the hot weather and rains the students are obliged for want of space to play football on the cricket pitch. This is scarcely desirable, as it cuts up the ground and renders it very difficult to get a good pitch in the cold weather. If the east side of the field was raised a little, this could be avoided. Two football grounds off the pitch could be laid out, and more practice pitches would be available in the cricket season. This will soon be necessary, as the native students are turning out to play in greater numbers. It is not desirable that the cost of this improvement should be charged to the club, which indeed could not afford it.

The gymnasium is not much used, the students turning out in a desultory fashion. It would give an impetus if a gymnastic instructor came down twice a week to give instruction, and if prizes were given at the time of the annual sports to the best gymnasts. The club could not afford to pay for the instructor. This should be a College charge.

The annual sports were held on the 21st February. Mr. Slater, President of the club, kindly undertaking to make all arrangements. According to custom some of the events were arranged, so that Europeans competed with Europeans, and natives with natives, the object of this arrangement being to give natives a chance of carrying off some prizes, but the result of the last sports shows that the division is no longer necessary. In throwing the cricket ball, in the high and long jumps the natives had a higher record this year than the Europeans; also in the tug of war a native team for the third time running pulled the European and Eurasian boys over.

At open sports for natives held in Dalhousie Square a team from Sibpur College won the tug of war.

Native and European students also play lawn tennis, which game has to be supported privately, club funds not being available.

Each year the President circulates amongst Native and European gentlemen, supposed to be interested in the College, a book for subscriptions towards the annual sports. It appears significant that this year the former subscribed Rs. 5 only, thus leaving the expenses to be borne by foreigners, and this in a College where 88 per cent. of the students are natives.

Health.

A report by the Resident Medical Officer on the health of the College during the year under review is annexed as Appendix A. From this it will be seen that there was a slight decrease of sickness, the average daily number of students on the sick list, excluding those laid up by accidents, being 6·03 or, as the average daily attendance was 253, 2 38 per cent, against 3·66 per cent. per diem last year.

An apprentice student died of cholera during the year. This is the first death on the premises amongst students since the opening of the College in 1880.

Workshops. Engineer students, with the exception of the senior class, attended shops daily, Saturdays excepted, from 1 to 3-30 p.m.

Senior apprentices were employed altogether in the shops upon such work as the Executive Engineer might determine. The other four apprentices classes attended shops daily from 8 to 11 a.m. except on Saturdays, when the hours were 8 to 10 a.m.

Mr. J. H. Toogood, Executive Engineer, took over charge of the shops from Rai Sarat Chunder Ghose Bahadur, Honorary Assistant Engineer, in the month of August 1890.

Rupees 12,000 have been sanctioned from educational funds for additional machinery, such as lathes, and also 5 additional native instructors and an instructor Foreman (European). It may now be expected that the shops may do really good, useful work from an edu-excational point of view, and will continue to do so, so long as an experienced Executive Engineer remains in charge.

Volunteers. The number of men in the College Volunteer Corps on the 31st March 1891 was 37. Of these, 4 were marksmen, 21 extra efficients, 12 efficients, and 4 proficients. The figure of merit of the Corps was 137·65 against 142 6 last year.

The rifle range near the College, alluded to in last year's report, has been completed, and will be available for shooting next drill season.

Twenty-three volunteers attended the camp of exercise at Jamalpore in February last, and were inspected there.

Library. Eighty-three books were added to the Library during the year. Of these, 53 were presented and 30 purchased.

SIBPUR;
The 24*th April* 1891.

S. F. DOWNING,
Principal, Civil Engineering College.

ANNUAL SPORTS.

ATHLETIC CLUB.

20th February 1891.

	Prize winners.
No. 1.—*Long Jump*, open to Christian students only.	F. Macguire.
„ 2.—*Long Jump*, open to native students only.	Nagendra Nath Samanta.
„ 3.—*High Jump*, open to Christian students only.	J. Parsons.
„ 4.—*High Jump*, open to native students only.	Nagendra Nath Samanta.
„ 5.—*Throwing the Cricket Ball* ...	1. Monmotho Kumar Bose. 2. C. R. Coxe.
„ 6.—*One hundred yards' Flat Race*, open to Christian students.	1. C. R. Coxe. 2. R. Young.
„ 7.—*One hundred yards' Flat Race*, open to native students only.	1. Nagendra Nath Samanta. 2. Monmotho Kumar Bose.
„ 8.—*One hundred and fifty yards' Handicap.*	1. C. Raynard. 2. Basanta Kumar Roy. 3. A. J. Chator.
„ 9.—*Quarter mile Flat Race* ...	1. R. V. Aguilar. 2. J. Parsons. 3. Surendra Nath Bose.
„ 10.—*Hardle-Race, 200 yards* ...	1. Nagendra Nath Samanta. 2. Upendra Nath Hazrah. 3. R. Aguilar.
„ 11.—*Three-legged Race* ...	1. A. Smellie and J. Morrison. 2. C. R. Coxe and J. Wilson.
„ 12.—*Sack Race*	1. A. Smellie. 2. J. Wilson. 3. Abinash Chandra Bose.
„ 13.—*Pick-me-up Race* ...	1. A. Smellie and J. Morrison. 2. C. Raynard and C. Tibbetts.
„ 14.—*Obstacle Race*	1. Upendra Nath Hazrah. 2. Basanta Kumar Roy.
„ *Tug of war*, Challenge Cup ...	Won by Native Team.
„ *Greasy Pole*	Annoda Churan Guha.
„ 17.—*Consolation Race* ...	Durgapada Bose.

W. M. D'C. & others—Reg. No. 4106J—70—22-4-92.